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MILLING AND CLASSIFICATION OF FELDSPAR

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THE title of this paper* suggests two thoughts: 1. the grinding of and subsequent classification of feldspar by suitable mechanical means as vibrating screens, air classifiers, etc.; 2. the classification referred to in the title is limited to the classification developed in 1930 at a general conference of feldspar producers, consumers and the United States Buerau of Standards. This classification is known as Commercial Standard CS23-30, and has been modified by the feldspar producers from time to time. The classification will be discussed more fully later.

The milling of feldspar has made considerable progress in several respects during the past ten years. Only a comparatively few years ago practically all feldspar was ground on chaser mills. These mills consisted of a large bedstone and two large heavy circular stones mounted on a horizontal axis, thus permitting them to rotate on the bedstone. Around the edge of the bedstone was provided a curbing which could be raised or lowered for the purpose of permitting the operator to obtain varying degrees of fineness. With the curbing raised to its maximum height the feldspar could be ground to a maximum fineness.

There are six classifications of feldspar which in turn are modified as to particle size, and by a great variety of chemical compositions. The need for further simplification of specifications is made clear.

In addition to the chaser mill type, ordinary buhrstone mills were used. These consisted of two circular stones with grooves cut into their faces. The under stone was usually the one that turned and the upper one remained stationary. The top stone had a hole cut in the center, through which the crushed feldspar was fed. By adjusting the distance between the faces of the stones and the manner of cutting the grooves it was possible to produce various degrees of fineness of the ground product.

Following these types of milling, batch mills were introduced. These mills were cylinders of various sizes, provided with pebbles as the grinding medium. The degree of grinding was determined by the length of time the feldspar was permitted to remain in the mill. The batch mill had an advantage over the chaser mills and buhrstone mills, for the reason no labor or attention were required during the grinding period. Some of the feldspar producers continue to use the batch type mill, because certain users of feldspar require their product ground especially fine, that is a ground product containing a high percentage of minus 325 mesh particles.

As time went on feldspar producers investigated more economical grinding processes, and have almost universally adopted pebble mills having continuous feed and discharge, operating in close circuit with air separators. The latter removes the "fines" from the product discharged by the mills, the "tailings" being returned to the feed end of the pebble mills for regrinding.

No detailed discussion will be entered into at this time regarding the various types of pebble and ball mills, the various designs of vibrating screens and the different types of air classifiers. It seems sufficient to say that practically all feldspar grinders are now using rock crushers, followed by pebble mills, and the product air classified in closed circuit, because this process seems to give the maximum degree of fineness at the lowest cost.

Approximately ten years ago, consumers of feldspar began to make known their desires regarding the particle size they desired. This was soon followed by specifications relating to the chemical composition they desired. For instance, the manufacturer of whitewares, such as electrical porcelain, vitreous and semi-vitreous dishes, floor and wall tile, vitreous sanitaryware, etc., called upon the feldspar producer to increase the percentage of "fines" or "flour" in the ground feldspar. The glass manufacturer at about the same time began to complain that the percentage of fines, namely, minus 200 mesh material, in feldspar was excessive and then began to ask that the feldspar grinder minimize the fines and try to produce feldspar with a more or less uniform particle size.

The grinder was faced with the problem of producing a fairly coarsely ground product and a finely ground product of mineral from the same mine or mines.

Practically all the feldspar consumers began along about this time to pay far more attention to uniformity and chemical composition than they ever had before. To meet these requirements was quite an interesting problem for the feldspar grinder.

Feldspar, as is well known, is a complex silicate that will vary in chemical and mineralogical composition, and in fusion characteristics, to a greater or lesser degree in the same mine or quarry. Feldspar producers approached this problem with a determination to accomplish worth-while results. The representatives of different feldspar companies discussed their problem frankly and fully with the consumers of feldspar, who

* From a paper delivered at the joint meeting of the Industrial Materials Division of the American Institute of Mining Engineers and the Material and Equipment Division of the American Ceramic Society.

took an active interest in this matter and visited various feldspar mines in different sections of the country, and at the same time inspected the equipment and methods used at the feldspar grinding mills.

The production of 20 mesh, semi-granular and granular feldspar for use by the glass manufacturer is still a difficult problem for the feldspar producers. The reason for this is, when the feldspar is crushed and later passed through rolls or pebble mills a considerable percentage of minus 200 mesh particles is produced. The cost of grinding glass feldspar with the present grinding equipment is considerably in excess of what it should be, because quite a large percentage of minus 200 mesh product is produced when attempting to grind the feldspar to 20 mesh, semi-granular or granular grinding. Perhaps one of the next developments will be to make it possible to grind 20 mesh particles without producing an excessive percentage of particles smaller than 200 mesh.

Although glass feldspar can be ground in closed circuit with air classifiers, this increases the cost of grinding. It is the desire of the feldspar producer to eliminate insofar as possible the added costs in producing particle sizes not desired by the glass manufacturer, in other words particles that are finer than 150 or 200 mesh.

The grinding of feldspar so that particles will all pass through a 20 mesh sieve is not an excessively expensive operation and is not as costly as grinding the feldspar particles so that 100 per cent will pass through a 200 mesh screen. The point is that there is an added expense when grinding to 20 mesh, by reason of the fact that a great percentage of the particles are reduced to a fineness of minus 200 mesh. It is desirable to eliminate this added cost if possible.

Stage grinding with rolls permits producing a higher percentage of 20 mesh and a lower percentage of minus 200 mesh particles. When pursuing this type of grinding it is advantageous to pass the ground feldspar over high-intensity magnetic separators to remove free iron particles in addition to the iron-bearing accessory minerals associated with feldspar.

Rod mills would probably reduce the cost of coarse grinding and would no doubt minimize the minus 200 mesh particles. If rod mills are used it is necessary to treat feldspar with high-intensity magnetic separators.

Removing the fines from feldspar ground 20 mesh, 40 mesh, 80 mesh, or 100 mesh, is one more operation in the preparation of the feldspar, therefore one added cost. Particles of feldspar finer than 80 mesh cannot be removed by mechanical screening, therefore it is necessary to resort to air classification.

The fines from feldspar suitable for use in the manufacture of glass are not always suitable for use in the preparation of feldspars for the manufacture of whitewares, or the manufacture of porcelain enamel frits. This again is a problem the feldspar producer has to meet, and frequently is more difficult to solve.

Another problem with which the grinder is faced at this time is the question of the yield of feldspar from different deposits. For instance, the richer feldspar deposits located relatively close to rail transportation have been more or less exhausted, therefore leaner deposits farther removed from the grinding mills are now being worked, with the result that the grinder is called upon to do more accurate preparation and milling in order to produce uniform feldspars.

The important developments in the production of feldspars during the past ten years may be stated as follows:

Giving full consideration to the demands of the feldspar consumers, it was and is vitally important that the feldspars be prepared in a manner insuring uniformity from shipment to shipment, and furthermore, giving full consideration to the numerous types of feldspar and their variation in nature it is obviously an important task to maintain uniformity of feldspar in each successive shipment. It should be remembered at this point that the establishment of adequately equipped laboratories, which of course include the technical personnel, have played a most important part in working out suitable procedures for the production of uniform feldspars. It is now possible for several of the feldspar producers to prepare their product having a chemical and mineralogical composition that runs remarkably constant from year to year. The next development of importance was the installation of suitable equipment for the production of granular and semi-granular feldspar for use in the manufacture of glass. This was followed by installations of high-intensity magnetic separators of the roll type, which permits the removal of free iron, black and white mica, tourmaline, hornblende, garnets and other iron-bearing and feebly magnetic accessory minerals.

Next we come to the classification of feldspars for the purpose of defining or identifying different grades to permit the producer and consumer to find a common meeting point when discussing feldspars, or placing orders for them, and in identifying them in a clear manner. The first attempt of a classification was worked out by a number of producers and consumers, along with the Bureau of Mines, and later printed as Commercial Standard CS23-30. The scope of this classification was to define the particle size and classify various types of feldspar by reference to their chemical composition.

The physical classification defines the degree of fineness or particle size. To illustrate: 20 mesh grinding according to CS23-30 represents feldspar ground so that 100 per cent will pass through a 20 mesh screen, U. S. Standard Sieve Series, and from 42 to 62 per cent will remain on a 200 mesh sieve. 200 mesh grinding is one in which the percentage remaining on a 200 mesh sieve varies from 0.35 to one per cent. Three groups were adopted with reference to chemical composition. The first group includes feldspars suitable for use in the ceramic formulas. These grades are based on silica content and alkali ratio and contain less than four per cent soda (Na_2O). These grades are referred to by number, for example, grade No. 67-51 designates a feldspar having a silica content from 66 per cent up to 67.99 per cent, and with five or more parts of potash (K_2O) to one part of soda (Na_2O). The numbers referring to the percentage of silica run from 65 to 73 inclusive. The numbers referring to the potash-soda ratio run from 61 to 31 inclusive.

Group 2 includes the feldspars used frequently for glazing purposes. They are based on a soda content containing from four per cent of soda up to 8.99 per cent of soda. Numerals are used to designate the percentage of soda and run from number 4 to number 8 inclusive. Number 4 is a glaze feldspar containing from

four to 4.99 per cent, while Number 8 glaze feldspar contains from eight to 8.99 per cent.

The 3rd group in the classification includes feldspars for use in the manufacture of glass and are based on silica, alumina and iron content. The numbers are to be used in combination, for example, grade 69-17-X represents a grade of feldspar containing from 68 to 69.99 per cent silica, 17 to 17.99 per cent alumina, with a maximum of 0.15 per cent of ferric oxide.

For full and complete details the U. S. Department of Commerce, Bureau of Standards, Feldspar, Commercial Standards CS23-30, may be consulted. Since the adoption of CS23-30 a number of changes have been made in the classification of feldspars, relating both to the chemical composition and the particle sizes. For instance, semi-granular and granular feldspar are now available and are defined as follows: Semi-granular having a minimum of 62 per cent and a maximum of 85 per cent residue on the 200 mesh screen. Granular having a minimum of 85 per cent residue on the 200 mesh screen.

The feldspar producers have attempted and have succeeded fairly well in classifying feldspars as follows:

1. Glass Grades
2. Enamel Grades
3. Whiteware Grades
4. Miscell. Grades
5. Glaze Grades
6. High Iron Grades

Each of these grades to be based upon particle size, chemical composition, or both, and/or purpose of use.

The glass grades shall be classified according to particle size and alumina. For instance, No. 16-20 mesh glass feldspar is one containing up to 15.50 per cent of alumina and ground so that all the particles will pass through a 20 mesh sieve. A slight tolerance in the chemical composition is permitted.

Enamel grades are classified according to the degree of fineness and the percentage of silica. For instance, 100 mesh number 70 is a feldspar containing 70 per cent or more of silica and the particle size is such that the residue remaining on 100 mesh will not exceed one per cent, and the amount remaining on a 200 mesh will vary from nine to 14 per cent. Whiteware grades shall be classified according to particle sizes or degrees of fineness and the percentage of silica. Miscellaneous grades are for use in the manufacture of soaps, cleaners and other non-ceramic purposes. Glaze grades are classified or defined as feldspars prepared and distributed for use in the manufacture of ceramic glazes. High-iron grades shall be classified and defined as feldspars containing more than 0.25 per cent Fe_2O_3. This is really the rejects from the magnetic separators and produced by feldspar grinders who have installed high-intensity magnetic separators.

Complete details will not be stated here for the reason the feldspar producers expect to publish a complete classification at an early date. The purpose of this paper is to illustrate how the classification has been developed.

DATA ON AN OLD GLASS PLANT

Several interesting facts about the glass factory illustrated here were sent to The Glass Industry by H. C. Rose of the Wightman Bottle and Glass Manufacturing Co., Parkers Landing, Pa. To quote Mr. Rose:

The Eclipse Glass Works, Thomas Wightman & Company.

"In 1879 the Parker City Glass Co. was organized, and operated under that name until 1882 when it was purchased by Thomas Wightman Glass Co. of Pittsburgh. Evidently, the Thomas Wightman Glass Co. of Pittsburgh had been in operation prior to either of the dates mentioned, and was owned by Thomas Wightman and his family. The plant of the Thomas Wightman Glass Co. of Pittsburgh as well as the plant here at Parker's Landing, was operated until 1907, when the name was changed to Wightman Glass Co. My information is that the Pittsburgh operation was closed at, or about that time. Both factories were in operation as day factories until in 1909 a continuous furnace was installed in the Thomas Wightman plant at Parkers Landing. The plant was operated as a hand plant until 1913 when the first machine was installed.

"The Wightman Bottle and Glass Manufacturing Co. of Parkers Landing is a continuation of the old Thomas Wightman Glass Co."

The Engineers' Council for Professional Development, a conference of engineering bodies organized to enhance the professional status of the engineer, has published the third annual report of its activities. Copies may be obtained at nominal cost from The Engineers' Council for Professional Development, 29 West 39 St., New York City.

1936 CHEMICAL ENGINEERING CATALOG

The 21st annual edition of the Chemical Engineering Catalog, which is subtitled "The Process Industries Catalog," has been published by the Reinhold Publishing Corporation, 360 West 42nd St., New York City. Fully indexed as to firm names, trade names, equipment and technical books, this publication with its attractive format furnishes an excellent reference book for the process industries.

Bausch & Lomb Optical Co., Ltd., has moved its London, England, offices from the historic Hatton garden section to Africa House, Kingsway, in the West End.

Paramount Pictures recently released another picture in the series of Popular Science films produced in color by Jerry Fairbanks. Glass men will be interested to know that many of the sequences were shot in the Bausch & Lomb plant. Scenes in the glass plant showing the fiery maw of the pot arches and shots of the fusing of bifocal lens segments are combined with demonstrations of scientific principles, such as the refraction of light and burst phenomenon of Prince Ruppert drops.

NEW YORK'S FIRST GLASS OFFICE BUILDING

Pioneering in its customary fashion, the Corning Glass Works has now under way the construction of the first truely glass office building in New York City, which may mark the beginning of a new New York, a city of glass towers. The new building will be five stories and front 27 feet on Fifth Ave. and 100 feet on 56th St. The facade will be built of glass blocks, each one foot square and four inches thick, separated by seams of lime Portland cement mortar one-quarter of an inch wide. These glass blocks will be set in a frame of Indiana limestone, the only stone in the building visible to the public.

The glass construction units are a development of the Corning Glass Works and are made of the same heat-resisting glass used in the manufacture of Pyrex ovenware. The unusually large size, compared with building brick, reduces the cost of installation and the number of mortar joints. The unit is one complete homogeneous piece of glass. It is hollow and consists of two square members sealed together at a temperature of 3,600° F. This is to insure the permanence of the block, to prevent non-dehydrated air from entering it and to prevent the formation of condensate inside the unit during cold weather. The most important physical characteristic of the glass is its coefficient of expansion, .0000018 for each degree of temperature change between 66 and 662° F.

The unit transmits 78 per cent of the light directed at a surface as compared with first-quality plate glass which transmits about 90 per cent. The brightness of a given source of light viewed in the line of light through a Corning glass construction is 11.6 per cent of the same light before it passes through the block. The brightness factor for ordinary plate glass is about 90 per cent. Of course, low transmission of glare is entirely separate from the question of light transmission. The above data are important as denoting a property of the Corning unit which cuts down harmful glare or brightness of exterior light sources.

Strength tests indicate that it would be possible to build a wall of these units 600 feet high without danger of their giving away under their own weight.

Studies on the thermal conductivity of the units indicate that a building equipped with them would be much cheaper to heat than a building furnished with ordinary single or double glazed windows. Tests on these properties are now being conducted and a report on them will be published in an early issue of THE GLASS INDUSTRY. The new building will, of course, be completely air-conditioned, and glass wool will be used for the insulation.

Two other features of the glass blocks are worthy of mention: Optical fluting running horizontally on one wall of the block and vertically on the other will obscure all images while transmitting a high percentage of light. Another feature is that in buildings with high humidity, the sweating of exterior glass surface is often objectionable. It is reported that with these Corning glass blocks, with an outside temperature of minus six degrees F. and an inside temperature of 70° F., there will be no sweating below a 52 per cent relative humidity.

Architect's drawing of New York's first glass office building being built for the Corning Glass Works at Fifth Ave. and 56th St.

Members of the Glass Division of the American Ceramic Society are advised that a meeting will be held, Oct. 23 and 24, at Cambridge Springs, Pa. From New York, Chicago, Cleveland or Cincinnati, the Erie Railroad goes directly to Cambridge Springs. The Pittsburgh and Lake Erie Railroad will serve the Pittsburgh area. As published in THE GLASS INDUSTRY last month, the program will be devoted to reports of the International Congress on Glass held in London, England, in July. The comparison of American practice with that in Europe will be given added interest by the presence in Cambridge Springs of many European delegates.

PITTSBURGH PLATE'S STORE FRONT CARAVAN

According to the Department of Commerce, who investigated some 8,000 stores, America's Main Street needs its face scrubbed and lots of new store fronts. Aware of this, Pittsburgh Plate Glass Co. is now sponsoring a "store-front caravan" consisting of two giant trucks and a pilot car which has just begun a 50,000 mile tour of the country. The trucks contain 12 model store fronts that will be on display in every important city east of the Rocky Mountains at some time or another during the tour, which will take from one to two years. Architects in all sections will be supplied with plans and details of these designs for use in their modernizing work.

NON-METALLIC MINERAL IMPORTS

In the near future the United States Tariff Commission will issue a volume giving comparative statistics of imports of non-metallic minerals for consumption by years for 1931-35. This work is being done as a W. P. A. project under the supervision of the Tariff Commission. Those interested should request the publication entitled "Comparative Statistics of Imports for Consumption, 1931-35, of Non-Metallic Minerals" from the U. S. Tariff Commission, Washington, D. C.

FUNDAMENTALS IN THE CHEMICAL ATTACK OF GLASSES

The following is an extract from the paper presented by Dr. E. Berger of the Department of Optical Research, Jena Glass Works, Germany, at the Second International Congress on Glass. Translated and extracted by Dr. Samuel R. Scholes.—The Editor.

THE special problem of the susceptibility of glasses to chemical attack arose about the turn of the century, when glasses of special composition appeared on the market. As chemists began to investigate the solubility of these and other glasses it became apparent that results were not entirely comparable, and that they depended largely upon the experimental methods employed. At present we are concerned with the possibility of some internationally acceptable method whereby comparable results may be had; using, for example, the same type of powder, the same temperature, mass of powder, and the same liquid. We would progress faster if we could develop certain constants which, independent of method, would describe the chemical attackability of glass. A good deal of work has been done recently in Jena on this problem. It has led to a certain conclusion, and the present paper deals with the measurement of chemical attack in general, and makes certain observations concerning its fundamental features.

Attackability and Chemical Stability

FROM the scientific point of view, chemical attackability must be regarded as a specific property of glasses, determined by composition and heat treatment. The constituent oxides of glasses are more or less strongly bound together. Similarly as in the presence of an electrical field, the weakest of these compounds dissociate, and separate components begin to wander; so under the chemical attack of a liquid or gases and vapors the weaker compounds of the glasses are destroyed. Chemical attackability thus becomes, in this view, a measure of the stability of the compounds in a chemical field of force. With a given liquid at a given temperature chemical stability will be determined by the composition of the glass and its thermal history.

A chemical attack proceeds from without to within, always taking place on the surface; and it therefore makes no difference whether one uses surfaces as in flasks or tubes, or broken pieces, powder, or grains. By reference to the universal surfaces all of these tests under the same conditions should lead to the same numbers for attackability as a property of the glass. Although fine powder, by presenting more surfaces, apparently introduces some difficulties, this question really has nothing to do with the true attackability of the glass and can be disregarded. We can always return to the measurable and definite surfaces of fracture.

It is important that the components of a glass combine in different degrees of stability and that therefore the attack of a liquid or vapor is selective. Solution of the components takes place in varying degrees. . . . . If the removal of a constituent is complete, the weight, z, of the decomposed glass can be determined from the quantity of this material carried into solution, n, and the quantity found in the original glass, N, by the relationship, $z = \frac{n \cdot 100}{N}$. The volume of this mass can be determined through the specific gravity, ρ, and from this, the surface being known, the thickness of the layer, x, can be determined as a comparable value for attackability.

The attack of hydrofluoric acid or of alkali in general carries all components into solution. Here the weight of the decomposed mass is equal to the loss in weight sustained. Conditions are less simple for attack by ordinary acids. From strongly basic glasses, all components except silica are carried into solution. If loss of weight is determined after heating to 500° in order to dehydrate silica, this loss divided by the sum of the per cents of all the components other than silica gives the mass of decomposed glass, z.

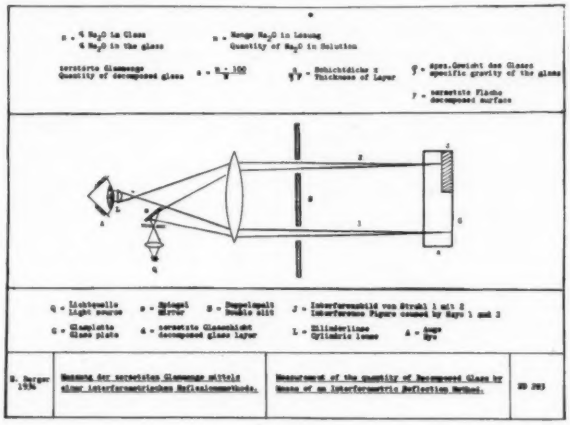


Fig. 1.

This can also be measured directly (see Fig. 1). A portion of the surface of a glass plate is attacked by acids, the rest being covered; a decomposed layer of thickness, d, results. By means of an interference apparatus the light from a source, Q, is reflected from this layer, d, and from the undisturbed surface, and brought into interference at the point, J. The absolute thickness, d, of the glass decomposed may then be calculated, index of refraction being known. A later paper will recite the procedure and the results of this method. Basically this interference method suffices for glasses less soluble in acid, and also for water attack for the measurement of the mass of decomposed glass, z, if the following conditions are fulfulled: (1) The decomposed and undecomposed glass must form a sharp boundary between regions with sufficiently definite refraction; (2) The thickness of the decomposed layer must be great enough to be measurable: that is, larger than 10 mμ. It is not yet certain that both these conditions can be realized in all cases of water or acid attack . . . .

The Fractured Surface and Pre-Solution[1]

THE formation of an altered surface layer influences the continuing course of the action of water or acids on the glass. The original attackability determined by composition and degree of annealing as a property of

[1] Translator's Note: The German word "Vorauslaugung," referring to the attack already made on a specimen, as by atmospheric moisture, before experimental treatment.

the glass is inhibited in the course of time, and overlain by the diffusion process. This renders difficult the testing of water solubility, since, because of the universal presence of water or vapor, most glass surfaces before investigation have already suffered a pre-solution of unknown duration and intensity. Fundamentally, therefore, the estimation of attackability as a constant of the glass requires an unaffected surface, which may easily be attained in a fractured surface. The most painstaking procedure would be to crush the glass in a vacuum, but in general surfaces freshly broken in the air fulfill all essentials.

Time Law of Chemical Attack and Pre-Solution

ATTEMPTS have often been made to express the relationship between time and the attack upon glass, by a mathematical equation. Starting from the fact that in the solution by water and acids we have to deal with diffusion processes through an altered glass layer, Keppeler[2] wrote the dependence upon time as the parabolic equation:

(1_a): $$s_2 = 2P \cdot t,$$

and found that it agreed with experimental evidence. Here, s refers to the weight dissolved in the time, t, expressed in any unit of measurement; for example, as the dissolved alkali. This parabolic law is to be expected for a purely diffusion process, if the true reaction with the glass goes very rapidly, and if the concentration of the liquid on the outer surface does not change. The removal of the dissolved material into the relatively large quantity of liquid must also take place very rapidly. During the experiment the liquid must be stirred, and that with such rapidity that the concentration of the dissolved material on the outer surface of the glass is reduced to zero. Every digestion, therefore, must fundamentally be conducted with maximal stirring.

We shall assume that, under these conditions, the parabolic law holds for freshly broken surfaces. Then for every interval of time the dissolved mass, s, can be calculated as

(2_a): $$s = \sqrt{2P \cdot t}$$

and P appears as the scientific constant which describes the chemical behavior or the attackability as a definite property of the glass. For general comparison, it is naturally related to the mass of glass decomposed and to the unit of surface. It is already anticipated in the powder method, and still more emphatically in the testing of plate glass, bottles, flasks, tubes, etc., that we have to deal with previously altered surfaces, pre-dissolved. Practically we start, therefore, not from the zero point of the curve given by the simple parabolic equation, (see Fig. 2) but with an essentially smaller velocity from some other point, A, on the curve and measure therefore from A, in the experiment the dissolved mass, σ, and the time, τ. But $\sigma + s_0 = s$; and $\tau + t_0 = t$; and our parabolic law becomes $(\sigma + s_0)^2 = 2P\ (\tau + t_0)$. Since $s_0^2 = 2Pt_0$ it follows that $(\sigma + s_0)^2 - s_0^2 = 2P\tau$ or,

(3): $$\sigma^2 + 2\sigma s_0 = (\sigma + 2s_0)^* = P\tau.$$

We obtained therefore, for the relationship of the new units, an equation with two constants of which one, P, is again the constant of attack from which,

[2] Keppeler and Thomas, Glastechn. Ber. 11, 1933, page 208.

* Translator's Note: This should evidently read $\sigma\ (\sigma + 2s_0) = 2P\tau$.

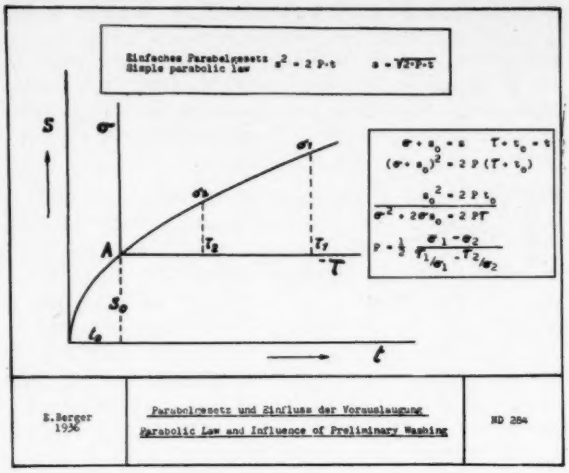


Fig. 2.

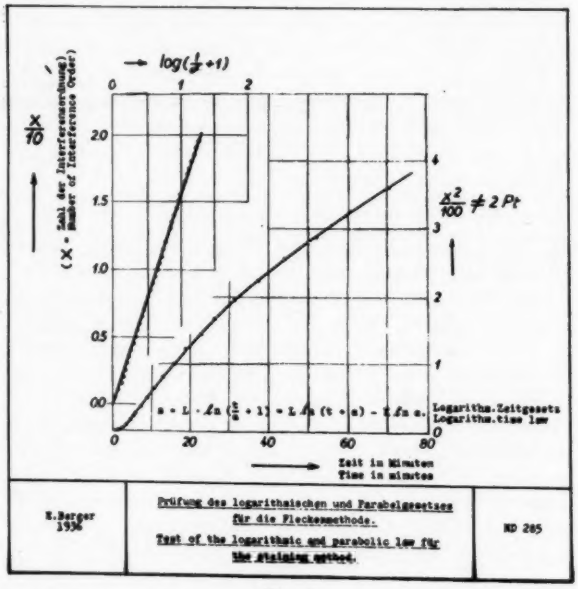

log(1/a +1)
X/10
Zeit in Minuten
Time in minutes
E.Berger 1936
Prüfung des logarithmischen und Parabelgesetzes für die Fleckenmethode.
Test of the logarithmic and parabolic law for the staining method.
MD 285

Fig. 3.

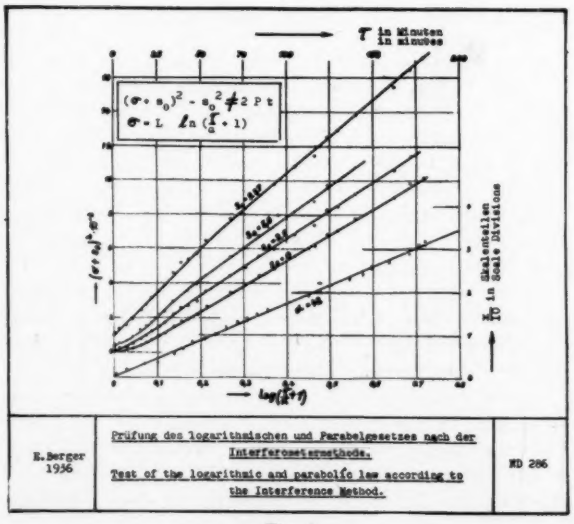

τ in Minuten
in minutes
E.Berger 1936
Prüfung des logarithmischen und Parabelgesetzes nach der Interferometermethode.
Test of the logarithmic and parabolic law according to the Interference Method.
MD 286

Fig. 4.

according to 2_a, the absolute constant of the glass is calculated; and the other, s_o, expresses a previously unknown value which reflects the degree of pre-solution. These constants can be regarded as two values of σ for definite solution times, τ_1, and τ_2, and we have; for example,

$$(4): \quad P = \frac{1}{2}\,\frac{\sigma_1\sigma_2(\sigma_1-\sigma_2)}{\sigma_2\tau_1-\sigma_1\tau_2} = \frac{1}{2}\,\frac{\sigma_1-\sigma_2}{\tau_1/\sigma_1-\tau_2/\sigma_2}$$

Careful testing of the attack by water or acids leads to the conclusion that the mathematical expression for the time relationship succeeds remarkably well through the introduction of a logarithmic function. In Fig. 4 the glass thicknesses, x, obtained by the interferometer method after acid attack, have been plotted quadratically against the time. One recognizes that $x^2 \neq 2Pt$ because x^2 against t plots in a curve, but if we plot x against the $\log \frac{(t+1)}{a}$ we obtain the expected straight line. Since the law in this manner possesses two constants, the slope, L, and the time factor, a, its authority can be established only through comparison with a parabolic law of two constants. In Fig. 4 therefore, is plotted $(\sigma + s_o)^2$ against t *on the one hand* for a similar experiment where the solution constant s_o was given the value of 0, 2.5, 5.0, and 9.7. One may give these constants whatever values he will but he obtains always, for long periods of time, a straight line, but they do not lead back to the point of beginning. *On the other hand*, the logarithmic time law, for a = 42 minutes, is again very well satisfied.

We now seize upon this time factor, a, as the measure of pre-solution. But the logarithmic time law points out that the value of the pre-solution, a, can never become quite zero because otherwise for all solution times, τ, the dissolved mass, σ, would become indefinitely large. Since, however, the logarithmic law seems by experimental evidence to be satisfied as to the smallest times (and that applies also to water solutions), it follows that a must be a limiting value. In view of the fact that the two-constant parabolic law is only approximately true, it follows, in any case, that the s_o of this law as a measure of pre-solution must be a limiting value. We name this limiting value "a," or "r," and we can then establish in general the following laws:

Without pre-solution: $s = L \log \frac{(t+1)}{a}$; $s^2 + 2sr = 2Pt$

With pre-solution:

$$s = L \log \frac{(t+1)}{(a+t_o)}; \quad \sigma^2 + 2\sigma\,(r + s_o) = 2Pt$$

On the one hand this means, that it is not possible, from a given time curve alone, to predict the estimate of pre-solution since the limiting value and the pre-solution always enter as the sum. On the other hand, it follows that the time law fundamentally requires at least two constants.

If Keppeler found that the parabolic law with one constant was established in his experiments it was only because he tested very soluble glasses at high temperatures where r takes on a small value. Indeed for glasses with less than 18 per cent alkali, he found noteworthy

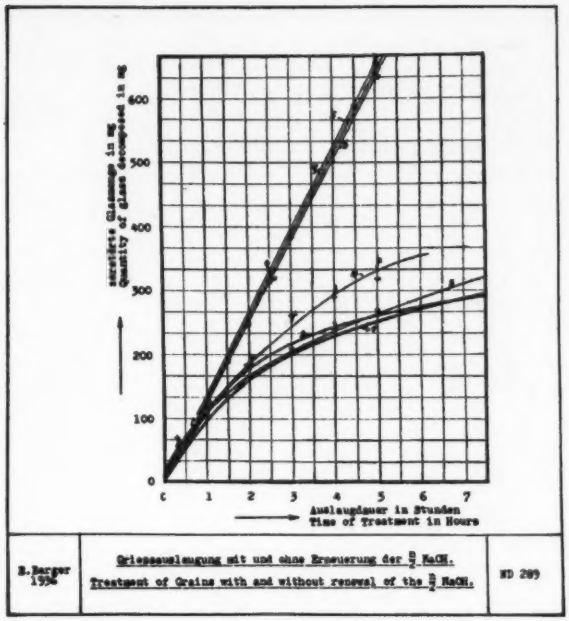

Auslaugdauer in Stunden
Time of Treatment in Hours
E. Berger 1936
Grieskornauslaugung mit und ohne Erneuerung der ½ NaOH.
Treatment of Grains with and without renewal of the ½ NaOH.
HD 289

Fig. 5.

differentiations, and these became more important as the digestion was continued at lower temperatures. The attackability of a glass can thus essentially never be determined by a single point of the time curve, that is, by a single measurement after one limited time of digestion, as the methods of the DGG and of Sheffield specify. This fact has already been noted many times[3]. One must always establish at least two points of the time curve in order to know how to make a definite statement as to the behavior of the glass for shorter or longer times of digestion than that of a single experiment. Two points of a time curve are indeed mathematically sufficient for the complete description of the definite or casual condition of the glass surface. If we wish to make statements as to the constants belonging to a glass it must in addition fundamentally undergo a previous treatment because otherwise the glass constants, a or r, remain undetermined.

The significance of these glass constants can be made apparent by observation of the differential time laws. These become:

With pre-solution:

$$\frac{ds}{dt} = \frac{L}{t+a+t_o} \qquad \frac{ds}{dt} = \frac{P}{s+r+s_o}$$

Without pre-solution:

$$\frac{ds}{dt} = \frac{L}{t+a} \qquad \frac{ds}{dt} = \frac{P}{s+r}$$

$$t = o: \quad \frac{(ds)}{(dt)_o} = \frac{L}{a} \qquad \frac{(ds)}{(dt)_o} = \frac{P}{r}$$

These differ from each other also in this: that in the logarithmic law, time appears in the denominator; in the parabolic law, the dissolved mass appears in

[3] For example: Jebsen-Marwedel and Becker. Glastechn. Ber. 10, 1932, 556; Keppeler, Glastechn. Ber. 12, 1934, 366; Preston, J. Amer. Cer. Soc 18, 1935, 220.

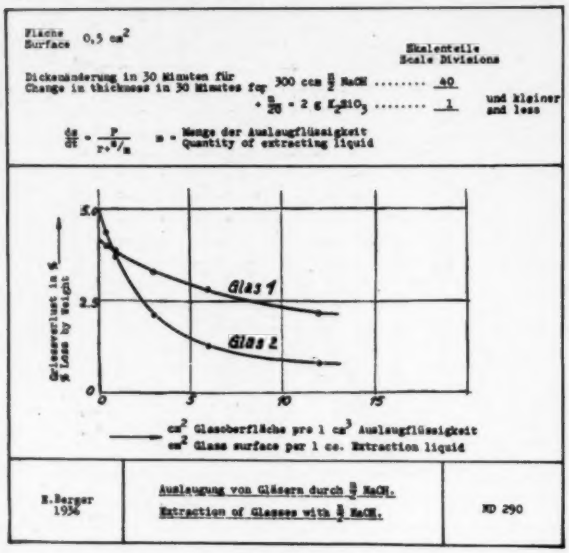

Fläche Surface 0,5 cm²
Skalenteile Scale Divisions
Dickenänderung in 30 Minuten für Change in thickness in 30 Minutes for 300 ccm n/2 NaOH 40
n/20 = 2 g K2SiO3 ..... 1 und kleiner and less
ds/dt = P/r·s/n n = Menge der Auslaugflüssigkeit Quantity of extracting liquid
Glas 1
Glas 2
Gewichtsverlust in % Loss by Weight
cm² Glasoberfläche pro 1 cm³ Auslaugflüssigkeit
cm² Glass surface per 1 cc. Extraction liquid
E. Berger 1936
Auslaugung von Gläsern durch n/2 NaOH.
Extraction of Glasses with n/2 NaOH.
HD 290

Fig. 6.

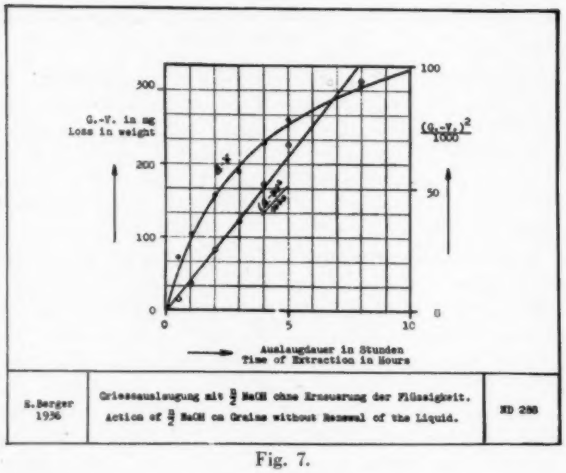

G.-V. in mg Loss in weight
(G.-V.)²/1000
Auslaugdauer in Stunden Time of Extraction in Hours
E. Berger 1936
Griesauslaugung mit n/2 NaOH ohne Erneuerung der Flüssigkeit.
Action of n/2 NaOH on Grains without Renewal of the Liquid.
HD 288

Fig. 7.

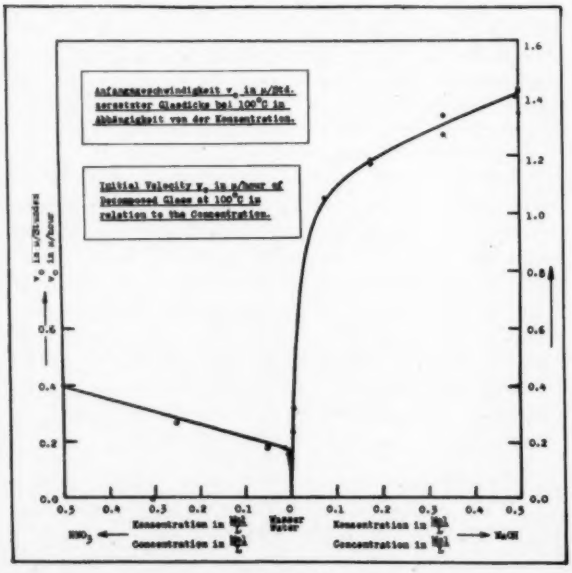

Anfangsgeschwindigkeit v₀ in g/Std. zersetzter Glasfläche bei 100°C in Abhängigkeit von der Konzentration.
Initial Velocity v₀ in g/hour of Decomposed Glass at 100°C in relation to the Concentration.
v₀ in g/Stunden v₀ in g/hour
Konzentration in Mol/l Concentration in Mol/l
Wasser Water
NaOH

Fig. 8.

the denominator. The initial velocities are equal to the ratio of the actual glass constants. The two laws stand therefore, in the relationship $\frac{(ds)}{(dt)_o} = \frac{L}{a} = \frac{P}{r}$ if a pre-solution may be safely predicated.

This relationship shows a certain formal similarity to Ohm's law: $I = \frac{E}{R}$, for an electrical circuit . . . . If we speak in similar manner of a solution stream which conducts portions of the glass through the surface into the liquid we have $\frac{(ds)}{(dt)_o} = v_o$ as the initial strength; L or P would be then formally the proportional difference of potential which arises through the affinity of the glass for the solute. Therefore, according to the kind and mass of dissolved components removed out of the glass under influence of the chosen liquid, finally "a" or "r" would be the resistance, which is conditioned somewhat by the stability of the soluble components in the glass.

The time law of solution may be expressed then, in general, in the differential form: the actual velocity of solution ds/dt is proportional to a certain potential difference of glass to liquid as well as to the reciprocal of a resistance. The latter consists of the sum of a specific resitance (r or a) added to an additional resistance (s_o or t_o), arising from pre-solution and an additional resistance, variable with the progress of the solution (s or t). In this abbreviated form all the single variables of the time law are brought together in visible form.

The Attack by Alkali

If a certain theoretical calculation should show that the analogy employed of a resistance does not rigidly hold; that much more the initial velocity v_o itself and not L or P supplies the specific reaction constant; we shall still hold to this picture, which presents the relationships quite simply, and proceed briefly to observe a further kind of resistance. This becomes especially noticeable upon the attack of glass by alkali, which we have as yet scarcely mentioned. For this attack, we assume that all of the altered glass is brought into solution. Therefore, no inhibiting layers, s_o and s, retard the velocity. The time dependence would be given; for example, by $ds/dt = P/r = v_o$; that is, the attack should proceed at a constant velocity. A series of experiments presented a differing picture.

Standard DGG powder occupying 4 cc. solid volume, with an external surface of about 1200 cm², was treated, with maximum stirring, for definite times, with 100 cc. N/2 NaOH. After the chosen reaction time the powder was filtered out, washed, and dried at 150°. The difference, compared with the original weight, gave the loss of the powder which corresponds to the decomposed mass of glass, z. Heating at 500° to dehydrate any hydrous layer made practically no change in z. The result of the single measurement shown in Fig. 6 is the accumulation of other similar ones. We obtained, therefore, a curve which as the plotting of z^2 against t shows, is practically a parabola and indeed one with very high initial velocity.

And yet one may not safely conclude from what has preceded, a pure diffusion process, as the following experiments indicate. The solution conditions here remain the same, save that, after each half-hour, 90 cc. of the reaction liquid was removed from the flask by means of a pipette and immediately replaced by 90 cc. of fresh N/2 NaOH previously warmed to 93°. The result of this experiment of renewal of the alkali is shown in Fig. 5 in curves Nos. 5, 6, and 7, which differ from each other essentially because of the manner of measurement of the altered mass of glass. We recognize that the measured values now arrange themselves along a straight line; that is, at last the anticipated uniformity of solution velocity is actually present.

Another experiment shows, perhaps still more certainly, the practical significance of this kind of behavior. With a similar quantity 100 cc. of N/2 NaOH, with the same time of solution, and equality of other conditions, only the weight of the powder and therefore, the ratio of powder surface to mass of liquid was changed. There resulted Fig. 6, where the actual loss of the powder is plotted against this ratio. Fundamentally, therefore, we may not compare directly the numerical values obtained, for example, in a flask method with those obtained from the powder method because of different ratios of glass surface to liquid.

That this influence is not to be explained by a change in the alkali concentration or the glass surface can be shown in the following manner: by protection with varnish only a small portion of 0.5 cm^2 of the surface of glass plate was exposed in a flask with 300 cc. N/2 NaOH with maximum stirring for thirty minutes. The change in thickness, against the protected surface, was measured by interferometer. Because of the quantity of fluid and the small quantity of glass dissolved the concentration of the alkali played no part and yet the surface remained quite large. Upon a repetition of the experiment two grams K_2SiO_3 was added to the soda solution in a concentration of N/20. There resulted a thickness change of at most one scale division against forty scale divisions by etching without K_2SiO_3. If concentration played a part the opposite result should have been expected.

Since not only silicate ions have appeared to be inhibiting, we must assume that only through the presence of components dissolved out of the glass is a hindrance to the attack called forth. For accurate measurement therefore, we must not conduct the experiments in a glass flask or use alkali which has been stored in or prepared in glass. Relationships are quite similar whether etching is done with soda solution or ammonia. In consequence of the inhibition, we obtain a curve of parabolic type, which we can explain approximately by a resistance changing with time, which we distinguish as the external resistance . . . . .

Upon inspecting the results set forth one recognizes that the attackability of glass presents a many-sided problem that nevertheless allows its dependence upon time to be expressed by a simple differential law. This law states that the observed speed of attack is proportional to an affinity between glass solution of characteristic magnitude, and the reciprocal of a sum of inhibiting resistances of constant and variable kind. The statement and evaluation of these resistances offers certain difficulties, especially for long times of attack, and is also disturbed by changes in the surface layer.

Finally the initial velocity, v_o, presents itself as the only invariant and scientifically definite property of the glass, which defines definitely at least, the behavior of freshly broken surfaces upon brief attack. For the further scientific treatment of the subordinate problems it is now of especial significance that this initial velocity possesses simple regularity; for example, it follows very well the law of Arrhenius, that is, the log v_o, plotted against the reciprocal of the absolute temperature, presents a straight line. The previous measurements with acid-soluble glasses show that these lines have equal slope; therefore, the dependence of initial acid solubility upon temperature appears to be quite independent of the composition of the glass.

Fig. 8 indicates further how the initial velocity v_o at constant temperature depends upon the nature of the attacking liquid; toward the right, the concentration of NaOH; toward the left, that of HNO_3 is plotted in mols per liter. As water concentration increases the observed initial velocities climb steadily on both sides until they soon run into steeply sloped lines. For considerable concentrations the initial velocity is therefore linear in its relation to the content of the liquid in acid or alkali. The position of the single straight portion of the curves relative to the water value is naturally different from glass to glass varying with temperature.

It is quite apparent we must differentiate between water, acid, and alkali attackability; and that information concerning attack by water for a certain temperature and time does not in any way suffice for a description of the behavior of a glass in use. From this knowledge we have recently sought to derive technical constants for behavior at other temperatures, and against acid and basic liquids. However welcome these attempts may be, their results will possess lasting value only if the following fundamentals are observed:

1. For a given temperature and solvent at least two values on the time curve must always be determined;
2. The glass must be obtained for measurement without pre-solution;
3. The area of the surface must be known;
4. The mass of glass decomposed must be known from the observed mass of dissolved material or be otherwise accurately obtained;
5. It is fundamental to work with maximum stirring.

It is above all important that it seems completely possible to develop true constants scientifically by the observation of a few fundamentals instead of depending upon so-called technical numerical values varying according to method. The previous testing processes do not need to be given up on this account. They are only to be developed as technical measurements. Frankly, the requirement that results be expressed in mass of glass decomposed, especially in water solubility, offers great difficulties. As a reward for the necessary pains, we shall have scientific constants, internationally acceptable and comparable.

Insurance rates for plate glass have dropped, according to an announcement by the National Bureau of Casualty & Surety Underwriters. Auto glass rates have dropped from $5 to $3 in most states; rates for plain show cases are down 25% and clamp show cases, 33 1/3%.

ECONOMICS OF RAW MATERIALS FEATURED AT JOINT MEETING

WITH an attendance of about 100, a joint meeting of three organizations: the Industrial Minerals Division of the American Institute of Mining and Metallurgical Engineers, the Materials and Equipment Division of the American Ceramic Society, and the Pittsburgh section of the A.C.S. was held at State College, Pa., Sept. 24, 25, 26. Headquarters for the conference were at the Nittany Lion Inn, and all papers were presented at sessions held in the Mineral Industries Building of the Pennsylvania State College.

Considering the meeting as a whole, there seemed to be a unifying theme running throughout. It was generally agreed that there were three major phases of the problem of industrial minerals: the producer's side of the question, the consumer's, and one of general economics.

The producers of raw materials are trying to give the customers what they want, and the consumers, in turn, are attempting, through stricter specifications, to define their needs. That those who supply industrial minerals have made great improvements in the last ten years in the care and control they exercise in mining, milling, storing, and shipping was acknowledged. Consumers at present seem to be asking primarily for greater uniformity of product. A specific request was voiced for a more uniform content of minus-200-mesh particles in ground feldspar.

Treatment of raw materials to increase their quality may be resorted to: 1. in order to make available cheaper materials in place of more expensive ones, of which the flotation of impurities from clays is an example; 2. to permit profitable operation on otherwise waste material, as shown by the flotation of limestone: 3. to open new supplies of raw materials, as is being done by the development of the kyanite industry in Georgia; and 4. to continue to supply the present demand. The latter is the problem facing the feldspar producers, who must search further afield, utilize leaner and more difficulty worked deposits in order to maintain production. Dr. George Otis Smith summarized this phase of the subject by the statement that every new development in beneficiation is equivalent to increasing the country's mineral resources and reserves.

Several papers of particular interest to glass men were read at the sessions and abstracts of them follow:

Milling and Classification of Feldspar, *By V. V. Kelsey, Consolidated Feldspar Corp., Trenton, N. J.*

Mr. Kelsey gave a detailed explanation of the classification developed in 1930 at a general conference of feldspar producers, consumers, and the U. S. Bureau of Mines, and known as CS23-30. He brought out, by means of examples, how the classification applies to feldspar for ceramic bodies, glazes, and glass, and how it affects the producers' grinding problems. The most difficult to produce, from the standpoint of economical grinding are the 20-mesh, granular, and semi-granular feldspars for the glass industry. An excess of fines is usually produced, frequently with a chemical composition not suitable for use in whitewares or glazes without expensive storing and blending. This paper is presented in full on page 333 of the current GLASS INDUSTRY.

The Kyanite Industry of Georgia, *By R. W. Smith, State Geologist of Georgia.*

The author described the production of kyanite from a belt of kyanite schist 30 miles long and ¼ mile wide. Beneficiation includes disintegration, washing and screening, followed by crushing of the recovered kyanite. Further washing and screening produces the separation of water ground mica, roofing granules (composed of quartz particles and a little fine kyanite and mica) and two sizes of sand. Mr. Smith expressed the belief that larger amounts of kyanite will be used in refractories for glass manufacture when the producers in this belt succeed in lowering the price in accordance with their expectations.

Magnetic Separation, *By G. W. Jarman, Jr. and S. G. Frantz, Separations Engineering Corp., New York.*

A consideration of the theory and practice of separating minerals of different magnetic susceptibility was presented.

Raw Material Requirements in the Whiteware and Glass Industries, *By E. H. Fritz, Westinghouse Electric and Manufacturing Co., Derry, Pa.*

The author made a general request for better materials without an increase in price, and gave the consumer's viewpoint of such problems as the size and shape of grains of crushed materials, and the removal of impurities from raw materials.

Limestone Beneficiation, *By Professor B. L. Miller, Lehigh University, Bethlehem, Pa.*

Lantern slides and motion pictures were used to aid in explaining the flotation process by which an impure limestone is adapted to the production of Portland cement. The savings resulting from the removal of excess iron, silica, or alumina more than repay the cost of the equipment needed.

Industrial Minerals Education, *By C. S. Crouse, Department of Mining and Metallurgical Engineering, University of Kentucky.*

Professor Crouse felt that education in the treatment of the nonmetallic minerals and their preparation for use in industry has not received the attention that it merits, and that the problem can be solved by cooperation between the industry and the schools.

Ceramic Materials Other Than Clays Abundant in California, *By B. M. Burchfiel, Director of Research, Gladding, McBean and Co., San Francisco.*

Read by title only; reprints were available to those in attendance. California produces feldspar, silica, talc, borax, and soda ash, and is independent of other states and countries so far as these materials are concerned.

Other papers read at the technical sessions included: "Air Separation of Minerals" by R. R. Slaymaker; "The Gypsum Industry of the Grand Rapids, Mich., District" by A. A. Mathews; "Flotation as a Method of Beneficiating Clays" by M. C. Shaw, Edward Orton, Jr., Ceramic Foundation; "Mining Practice in the Bell-Mine Limestone Mine" by S. M. Shallcross, American Lime and

Stone Co.; "Limestone Sand" by A. T. Goldbeck, National Crushed Stone Association. "Clay Mining Methods" by E. J. Lintner, U. S. Bureau of Mines; "A Modern Ball Clay Operation" by Richard Bell, Bell Clay Co., read by C. W. Hall, United Clay Mines Corporation; "The Wire Saw as a Tool for Cutting Slate and Building Stone" by Oliver Bowles, U. S. Bureau of Mines.

Honoring President F. C. Flint and General Secretary R. C. Purdy, the Penn State Student Branch of the American Ceramic Society held a dinner Thursday evening. Professor N. W. Taylor, head of the ceramics department, as toastmaster called upon the guests for short, informal talks. The dinner was followed by an inspection of the laboratories of the ceramics department.

At an informal dinner Friday evening, toastmaster Edward Steidle, dean of the School of Mineral Industries, introduced as speakers F. C. Flint, President of the A. C. S.; R. C. Purdy, Secretary of the Society; Oliver Bowles, Chairman of the Industrial Minerals Division, A. I. M. E.; Adrian Morse, Assistant to the President, The Pennsylvania State College; and G. O. Smith, past director of the U. S. Geological Survey, representing the president of the A. I. M. E.

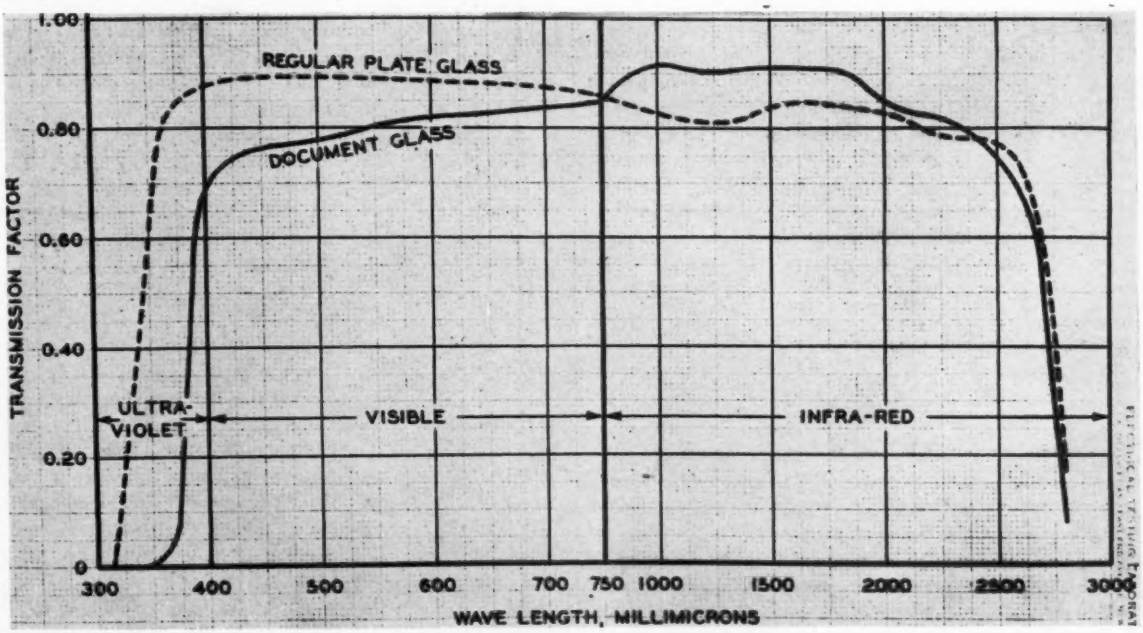
Another feature of the meeting was an inspection of the Bell Mine and plant of the American Lime and Stone Co. at Bellefonte, Pa., about twelve miles from State College. Approximately 50 visitors were lowered to the 600-foot level of this large underground limestone operation, where the mining methods employed were explained by S. M. Shallcross, general manager.

The committee on local arrangements for the gathering consisted of Professor C. A. Bonine, Department of Geology, Chairman, Professor W. R. Chedsey, Department of Mining and Geophysics, and Professor N. W. Taylor, Department of Ceramics. Ladies' entertainment was arranged by a committee under the leadership of Mrs. Edward Steidle.

DOCUMENT GLASS

The research laboratories of the Pittsburgh Plate Glass Co. have developed a special glass known as "Document Glass" which is to be used in protecting valuable papers and manuscripts from deterioration by light. As research work conducted by the Swedish National Testing Institute in Stockholm showed that the ultra-violet portion of the spectrum, i.e. the wave lengths shorter than 400 millimicrons, is very destructive to paper stocks and inks, the composition of "Document Glass" is such that the ultra-violet portion of the spectrum is filtered out and the visible portion allowed to pass. The spectral transmission of this glass is such that, while nearly 97 per cent of the injurious radiations are absorbed, the visible transmission is not seriously impaired and the visibility is therefore not affected.

An installation of the new glass has been made by the New York Historical Society, at its museum at 175 Central Park West, New York City, where a special case using the glass has been constructed to prevent further deterioration of three rare and interesting documents of the American Revolutionary period. The papers thus protected are George Washington's acceptance of the freedom of the City of New York, written and signed in his hand, in 1783; the Articles of Surrender of General Burgoyne at Saratoga, N. Y., in 1777, the British defeat generally regarded as the turning point of the Revolution; and a British orderly's notebook, opened to a terse entry concerning the execution on September 22, 1776, of an American spy—the only known record of the death of the patriot, Nathan Hale.



The transmission measurements of "Document Glass," as compared with ordinary plate glass. In the ultra-violet group of wave-lengths (below 400 millimicrons), which are those that cause by far the greatest chemical effect, "Document Glass" transmits an appreciably smaller percentage of the rays at every wave-length. In the visible section of the spectrum (400 to 750 millimicrons), the rays which have only a limited effect chemically, document glass transmits nearly as high a percentage as plate glass.

G. C. A. REPORTS RECORD YEAR FOR INDUSTRY

CONTINUANCE of improved conditions in the glass container industry was indicated at the semi-annual meeting of the Glass Container Association, held at Atlantic City, Sept. 23-25. Industry statistics as reported by the Association show that more containers of all types were produced during the first eight months of 1936 than for the same period in 1935, the previous all-time high. Or, compared with 1929, the great year of plenty for glass as well as for most industries, the industry showed a substantial gain.

This improved demand has been shared by nearly all lines. Beer and liquor containers showed the largest gains; but even discarding the tonnage they represent, on the theory that neither beer nor liquor ware was produced in 1929, the remaining "general line" production was still ahead of any former year. The only classifications to lose ground were fruit jars and jelly glasses. For the past four months many container factories have experienced delay in filling orders, in spite of the fact that the industry has been operating at only 65 per cent capacity. Needless to say, this condition is being rapidly remedied, and a proportion of the inactive productive capacity will soon be placed in operation.

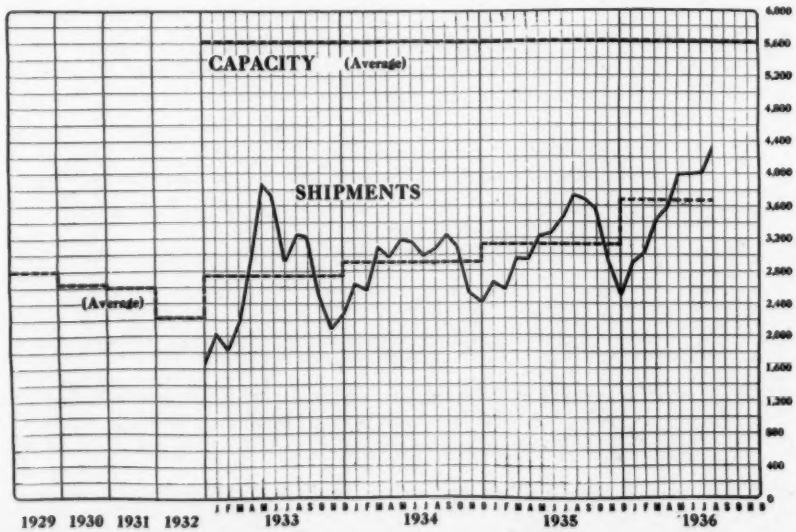
Activities of the Association during the past six months reflect one of the most interesting periods in its history. Many important projects and much tangible accomplishment has been effected by headquarters in New York City. In reporting these details to the convention, assistant business manager E. G. Ackerman stated that the effectiveness of the Association's activities in promoting the industry's welfare has been due in no small degree to the fact that the Association included practically the entire industry.

Standard Testing Procedure. To afford better protection for the manufacturer of glass bottles against what is generally referred to as the "damage suit racket," the Association appointed a committee last spring to study the situation. In June, the Committee invited manufacturers to a meeting in Washington, D. C., which was well attended and which provoked much discussion. Here it was found that interest in the subject goes considerably beyond the mere testing of bottles as a means of defense in damage suits, but extends to the processes of glass making itself. Readers of THE GLASS INDUSTRY are familiar with this latter development, which has strongly flavored the proceedings of the Glass Division and the recent International Conference. Because of the larger aspect of the problem, the Committee at this time is unable to do more than report progress. However, it hopes to be able to offer very shortly some very simple testing procedure that will answer the purpose temporarily until the industry's technologists can offer something more permanent.

Light Weight Containers. Last spring the development of standard light weight containers for certain lines of glass packed products was discussed. This work is progressing, and it is expected that the work of the committee will assume importance in developing the market for glass containers.

Tariff. Importations of Japanese bottles are increasing, and at the present rate of increase will soon become a serious problem. Also the government is negotiating a reciprocal tariff treaty with Germany, an important bottle producing country. The Association will oppose bottles being considered in the treaty because any reduction in rates would carry through all other countries producing bottles.

Traffic. Interest at the present time centers on a new schedule of freight rates which the railroads are preparing to put into effect Jan. 1. The object, of course, is to preserve permanently, the emergency charges that expire on that date. Some of the objections the Association lists to the increase are: 1. it would bring about much higher costs to long haul traffic, thereby dislocating sales of competitive manufacturers shipping to the same market. This becomes particularly important in large cities; 2. it would tend to force the building of new factories near large consuming centers and force the abandonment of some less favorably located. 3. weaker and smaller companies, financially unable to relocate their plants, would be forced out of business.



Total industry shipments in thousands of tons compared with production capacity by months.

Standardization. At present the Standardization Committee has before it 13 new finishes and revisions are under consideration covering 18 present finishes. New finishes being considered include three lug types, several being used for lubricating oil bottles and additional ones for pharmaceutical, liquor and wine bottles.

Work has been conducted on a program of co-operation with manufacturers of bottle handling machinery. Additional contacts with machinery companies have been

GLASS CONTAINER INDUSTRY EMPLOYMENT, PAYROLL AND COSTS
1935 COMPARED WITH 1914

	1914	1935	Per Cent Increase or Decrease
Total Gross Shipped	19,196,000	37,641,539	96.09
Total Tons Produced	959,800	1,897,125	97.66
Value of Products	$51,958,728	$112,307,771	116.15
Value per Gross	$2.71	$2.98	9.96
Wage Earners accounted for	40,103	39,956	—0.37
Payrolls accounted for	$28,311,314	$48,250,061	70.43
Average Annual Wage	$706	$1,208	71.11

Employment and Payrolls Accounted For

	Employment		Payrolls		Average Annual Wage	
	1914	1935	1914	1935	1914	1935
Glass Container Factory	31,290	24,044	$20,460,000	$26,164,836	$654	$1,088
Employees, Office and Sales	1,770	3,074	2,740,000	6,292,626	1,548	2,047
Materials and Fuel Industries	3,447	6,134	2,205,726	5,748,515	640	937
Equipment and Mold Mfrs.	....	894	.....	1,282,000	....	1,434
Transportation Agencies	3,596	5,810	2,905,588	8,762,084	808	1,508
Totals	40,103	39,956	$28,311,314	$48,250,061	$706	$1,208

Comparison of Prime Costs

	Total Value		Cost per Cwt.	
	1914	1935	1914	1935
Glass Container Payrolls	$23,200,000	$32,457,462	$1.209	$.855
Basic Raw Materials	6,119,397	16,121,390	.319	.425
Fuel	2,045,334	4,208,391	.106	.111
Package Materials	4,799,000	19,155,000	.250	.505
Transportation (outbound)	4,103,145	12,805,596	.214	.338
Taxes (Federal, State and Local)	370,500	4,568,700	.019	.120
Totals	$40,637,376	$89,316,539	$2.117	$2.354

(Source of data: 1914—U. S. Census and 1935—G. C. A. and affiliates)

made for the purpose of becoming better acquainted with their problems. The Committee has recommended that the Association prepare a booklet covering bottle designs with illustrations of types which lend themselves to proper handling in high speed filling and labelling machines together with illustrations of some of the freak shapes which are expensive to manufacture and which do not handle properly.

Another phase of this work recently instituted has to do with the standardizing of neck diameters. This department has also co-operated with the Beer Bottle Committee in preparing standard specifications covering the new style Stubby and Steinie bottles. In addition to these new styles, prints showing capacity, weight and body specifications for all standard style beer bottles are ready for issuance. Through these bottle standards it should be possible to gradually eliminate special shapes and sizes. This should be a real benefit to the brewery trade and in addition should help to reduce mould costs in the industry. It is also believed that benefits will accrue through an extension of this work to other standard containers such as water bottles, ginger ales, sodas, etc.

Beer and Milk Bottles. A major activity of the Association the past year has been its counter-propaganda against canned beer and against milk in paper containers. Consumers have been led to believe that these other containers are just as acceptable, or more so, than glass. And the Association's defense has been to conduct research, discover the real facts, and give the findings the widest possible publicity. It is difficult to establish in dollars and cents just what the outcome has been. But the following is significant: the volume of beer bottles the past year has been 94 per cent over 1935, and milk bottle production has increased 22 per cent over 1935.

Payroll Analysis. One of the outstanding features of the meetings of this Association has been the statistical reports by Victor L. Hall, covering the production of the industry. Some of Mr. Hall's most interesting data have been reported in our opening paragraphs. This year, the statistician included a new feature—an analysis of employment, payrolls and costs, given on this page.

Entirely aside from the insight which these figures afford into the magnitude of the industry and the gains it has made over the last 20 or more years, they throw a light on the labor situation which is particularly needed at this time. It has been charged of all industry that each and every machine throws many laborers out of employment; or, as applied specifically to glass, that a single glass machine today does the work of 35 workers. Also it is charged that wages have not kept pace with increased living costs. Much political capital has been made of these supposed conditions, and the divergent interests of capital and labor have been emphasized as a result. What is the true situation in the glass industry, which these figures show?

1. That while the number of workers employed in glass container factories actually has fallen off some 23 per cent since 1914, yet the gains in tonnage have given employment to the raw material, mould, transportation and allied industries to an extent almost exactly counterbalancing the shrinkage. Expressed numerically, while the number of glass workers dropped from 31,290 to 24,044, the total of workers affected dropped from 40,103 to only 39,956. The decrease is negligible—about a third of 1 per cent. As this affects the individual factory worker,

(*Continued on page* 356)

CLASSIFICATION OF TANK FURNACES

By Professor S. S. Berman

This is the second instalment of an article on classification of tank furnaces by Professor Berman, a well known Russian scientist. The first instalment dealt with such topics as methods of tank division, utilizing heat of waste gases and flame direction in furnaces. The present paper is concerned with designs of throat furnaces.—Ed.

Designs of Throat Furnaces

The classification proposed in the September Glass Industry can be developed further. It is especially important in respect to furnaces with a throat or a lateral construction, since both of these types are widely adopted and modern. With regard to American furnaces with a dog-hole, two factors form a basis for this classification: the depth of the dog-hole; the outlines of the furnace.

One can distinguish between an ordinary dog-hole, i.e., a dog-hole with its bottom on the same level with that of the tank and the so-called sunk throat. The depth of immersion in the latter type can vary. The purpose of such an immersion is a logical accomplishment of the hydrostatic law of glass division, i.e., the draw of the glass-mass from the bottom of the melting end. From this view-point, this method seems quite logical and expedient for manufacturing small articles of high quality such as domestic wares, since it results in a maximum removal of the layers of glass on the bottom of the melting tank, as well as of the so-called dead glass, since the latter has a bad influence on the quality of glass.

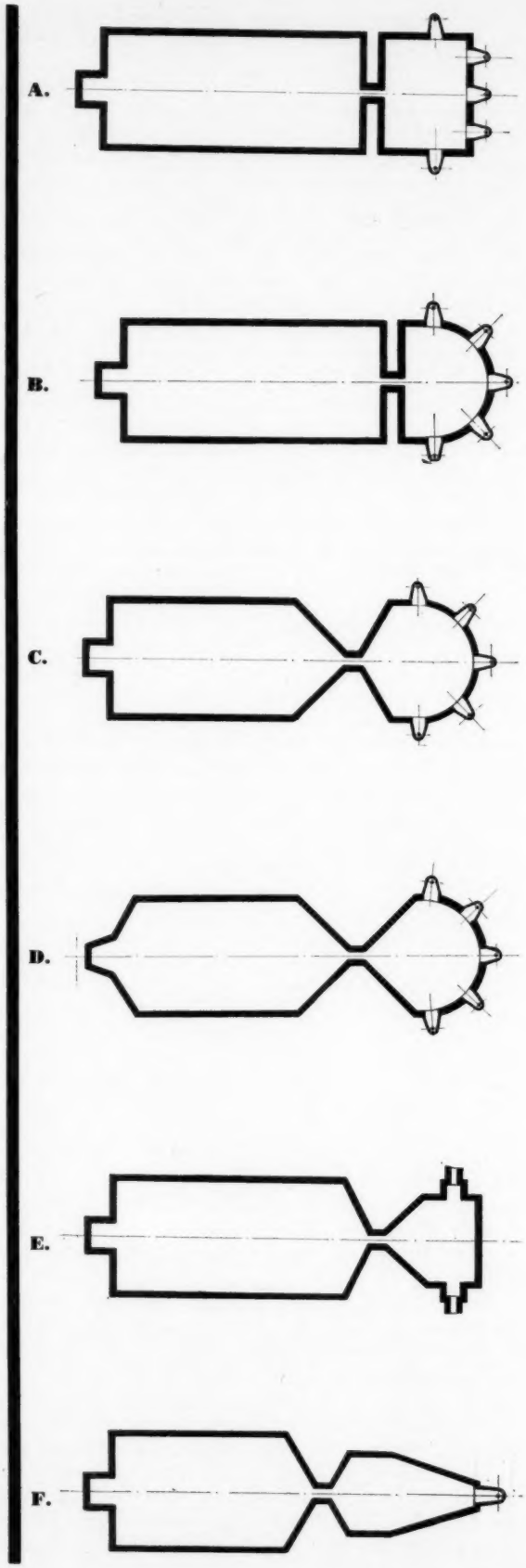
In the production of glass of lower qualities and of colored glass the immersion of the dog-hole is not called for since in the first instance it is unnecessary and in the second, it can cause difficulties in operation due to the freezing of glass in the throat.

Sometimes the throat is situated higher than the bottom of the basin, thus forming a projection[8]. Apparently, this construction was suggested in order to protect the bottom blocks from corrosion. However, this is done at the cost of the formation of dead or unmovable layers in the glass-mass which can adversely affect the quality of ware. For this reason such an elevated throat has not been widely adopted.

The second factor to be discussed deals with the outlines of the furnace. Different outlines of American throat furnaces are shown on Fig. 4. Section "a" shows rectangular outlines for both basins (the melting and working end), which were designed for the first furnaces of this type. A description and drawings of a furnace with analogous outlines is given in the Dralle Keppeler book, "Die Glasfabrikation," vol. II, pp. 1348-1350 and table XIX.

Section "b" of Fig. 4 illustrates a working end with a rounded outline. The walls of the throat are as before parallel. Such a configuration is used frequently, especially in the U. S. A. The purpose of such a rounded

[8] Dralle-Keppeler, Vol. II, pp. 1125-1126, fig. 1134.



• Fig. 4. Design of throat furnaces: A. With rectangular basins; B. With rounded outline of the working end; C. With rounded outline of the working end and bevelled walls of the throat; D. torpedolike; E. For two machines; F. For one machine.

outline is to avoid dead angles in the working end and to give a more uniform supply of glass to the machines.

The next design involves the splaying of the walls adjoining the dog-hole in either of the basins. This method facilitates, on one hand, access to the dog-hole, thus providing not only a better cooling, but also affording a possibility for minor repairs. On the other hand it may be supposed that in this way the dead corners can be avoided in both basins. The scheme of a furnace with a rounded working end and a dog-hole with bevelled walls, is given in section "c."

A further development of this idea consists in the splaying of all corners in both basins; thus we obtain a torpedolike furnace proposed first by the English designer Moorshead and shown in section "d."

Section "e" shows the outlines of a furnace for two vacuum machines. Its chief distinction is the outline of its working end, a triangle which ought properly to be called a trapezium with two of its apices lying near the machines and the third represented by the dog-hole. An outline of the kind is necessary for the elimination of stagnant glass in the presence of two machines.

Section "f" shows the outlines of a furnace with one machine. The working end is elongated in the direction of this machine.

Designs of Waist Furnaces

Furnaces with a dog-hole have many advantages as compared to single chamber furnaces. Their chief advantage is a considerable increase in specific output, i.e., the quantity of melted glass per unit of glass surface, which results in a considerable decrease of specific fuel consumption.

A second no less important advantage is the almost entire independence of the regime in the working end and in the melting tank, a fact of special importance in mechanical production of glass. And finally, an advantage of the above method is the possibility of reducing the dimensions of the working end, within limits compatible with the frontage necessary for working either by machines or by hand.

The cooling of the glass-mass in the dog-hole is in some respects an advantage, but at the same time from other viewpoints a serious drawback in furnaces with a dog-hole. The cooling of the walls of the throat must be intensified since otherwise, the walls and lintel might become subject to severe corrosion. In Malyshev's furnaces where the dog-hole was never cooled it suffered generally from the rapid wear resulting often in the leaking of the glass through the walls and bottom of the dog-hole.

On the other hand, if the walls of the dog-hole be cooled very intensively, the glass-mass will also be cooled and the part moving peripherically in the dog-hole might be cooled more than the central flow. Owing to the low heat conductivity of glass, the temperature difference must be very pronounced. Taking into account also the small section of the dog-hole it may be imagined that the temperature gradient in the cross section of the dog-hole must be considerable. All of this results in the introducing of a thermally inhomogenous glass into the working end, a fact which in turn can cause defects in the resulting glassware. These defects increase with the intensifying of the cooling of glass on one hand and with the increase of the dimension of the manufactured products on the other hand.

In the production of small articles by hand or with press and blow machines, which gather the glass from small areas, the thermal inhomogeneity usually does not affect the quality of the wares. Therefore such furnaces are suitable for the manufacturing of bottles, domestic glassware, electric glass bulbs, etc. On the other hand a number of practical facts have proved the inexpediency of constructing a furnace with a cooled dog-hole for the manufacture of machine-made window glass and plate glass. Several rather unsuccessful attempts in this direction were made; the reason for these failures was the thermal inhomogeneity of the glass in furnaces with a dog-hole. This degree of thermal inhomogeneity, permissible for bottle and table glass, is inadmissable for window glass and plate glass for two reasons.

The first reason is the considerable difference in the dimensions of the articles, a fact requiring no further discussion. Second, the technological process of mechanized production of window and plate glass usually sets more severe conditions regarding the thermal homogeneity of the glass-mass; therefore the slightest inhomogeneity reduces the quality of the ware.

This can be illustrated by an example in the production of window glass with Fourcault machines. It is known that the thickness of the drawn sheet, other conditions being equal (the rate of ribbon drawing, the chemical composition of glass, the dimensions of the "debiteuse" and of its slots etc.) depends on the viscosity of the glass-mass or in other words on its temperature; the higher the temperature, the thinner is the glass and vice versa; therefore the slightest variations in the temperature of the glass-mass, have a marked influence on the thickness of the sheet.

Now supposing that the flows of glass entering the slot of Fourcault's debiteuse be of various temperatures, the glass thickness in different points of the slot will be different, and the result will cause "lines" to form in the glass, the "lines" being parallel to the direction of drawing. These "lines" are the result of local thickening and thinning of the glass and they form the main defect of window glass produced by the Fourcault method.

Considering the advantages of the constructional division of the tank into several separated compartments on one hand and the inexpediency of artificial cooling of the throat and division walls in the production of sheet glass, the author of this article proposed and worked out a new type of furnace with separated basins for mechanical production of window glass by the Fourcault method. Eight furnaces of this construction are already in operation and are supplied with 98 Fourcault machines. Several such furnaces are at present being built.

The principle of this furnace is as follows: the glass melting furnace comprises two basins united in the melting zone by a constriction passing through the whole depth of the glass and sufficiently wide to prevent any thermal inhomogeneity of the glass-mass entering the cooling zone. A floater is situated in the waist; its depth can be changed thus permitting regulation of the temperature of the glass-mass on its entering the cooling zone. Both tanks are covered with separate crowns, the waist being covered by a small crown placed very low

• Fig. 5. Designs of tank furnaces with waists: A. Rectangular basins; B. The walls of both basins bevelled at 45°; C. Both basins of cigarlike outline; D. Rectangular basins—absence of throat between the tank and the canal of Fourcault; E. Both basins with a cigarlike outline—absence of throat; F. The Fourcault furnace and canal on its own axis.

above the melt. A movable or fixed bridge can be installed in the waist to permit either an entire separation of the combustion space of both basins or a regulation of the communication between the two. Several outlines of furnaces with a waist are illustrated in Fig. 5.

Section "a" of Fig. 5 shows the plan of a furnace with rectangular outlines of both basins. Such a furnace is reconstructed from a Gobbe furnace in one of our factories which is supplied with 12 Fourcault machines. The rectangular outline of the furnace is due to the fact that the problem of furnace reconstruction was set before us only after completion of the Gobbe furnace and the latter had to be rebuilt with minimum expenses and demolishing. The reconstruction itself was carried out in a very simple way, only one of its sections being pulled down, thus making room for the installation of a waist. Nothwithstanding the rectangular outlines of the basin, the effectiveness of the furnace is very high both in quality and in quantity.

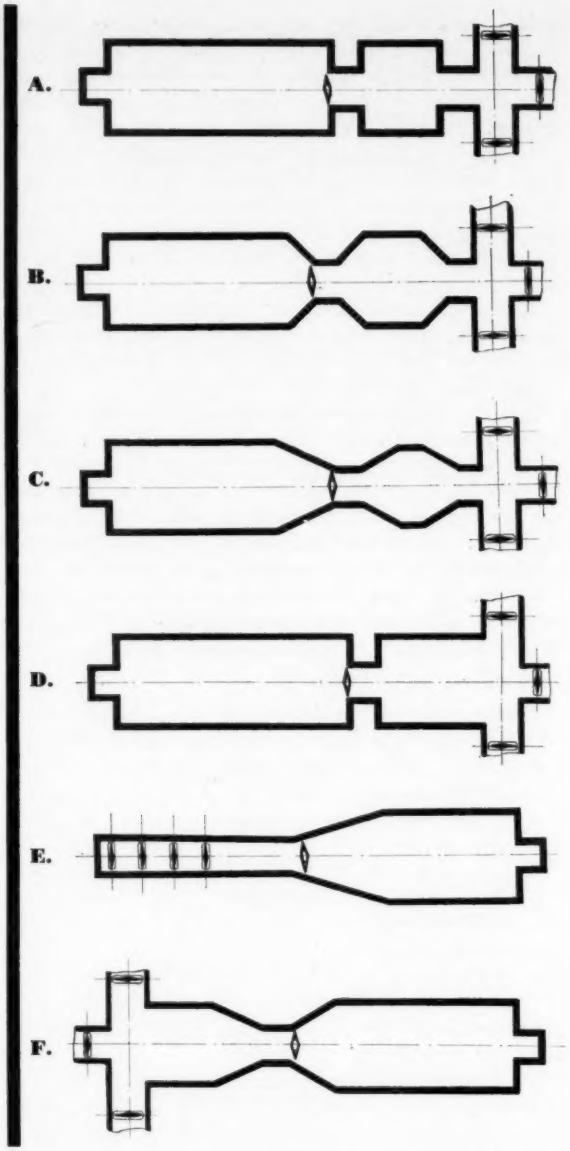
Nevertheless it is expedient to bevel the walls of the waist. Section "b" of Fig. 5 shows a drawing of a furnace, which differs from precedent because of the bevelling of its walls in both tanks at 45°. The first furnace with a waist was built according to this principle and carried 14 Fourcault machines. The operation of several furnaces with waists showed the necessity of a maximum even outline of the tank between the melting zone and the cooling zone, as well as between the latter and Fourcault's canals.

Section "c" shows a furnace with its cooling and the end of its melting zone having a cigarlike outline. Three furnaces of this type, each with 13 Fourcault machines, are already in operation. This furnace is marked by an even passage between the melting tank and the cooling compartment, as well as between the latter and the Fourcault canal.

Section "d" of Fig. 5 illustrates a furnace differing from the above-mentioned furnaces by the absence of a throat between the cooling zone and the Fourcault canal. The glass is transferred directly from the cooling zone into the Fourcault canal, the absence of a throat being undoubtedly a positive factor. Two furnaces each with 10 Fourcault machines are already in use.

Section "e" shows a furnace, where smooth outlines of both tanks are accompanied by the absence of a throat between the cooling zone and the Fourcault canal. This measure permits not only the production of glass of higher quality, but at the same time the enlarging of the space of the melting zone. In other words, the working capacity of the furnace may be increased, other conditions being as before. Construction of a new tank furnace was carried out according to the above principle with 12 Fourcault machines and the reconstruction of one of the working furnaces for 13 Fourcault machines; the reports concerning the operation of the latter are exceptionally favorable. Another small tank furnace with four Fourcault machines also was designed starting on this principle.

Section "f" represents a cooling zone, elongated from the melting zone, and a small Fourcault canal, in its turn a mere elongation of the cooling zone. In this combination is realized the principle of even lines and straight flows.



During recent years the direct joining of the machines and tanks of furnaces (that is the installation of the machines in the peripherical parts of the cooling zone) has found general recognition. In particular it has proved to be expedient to employ for this purpose the outlines of the furnace presented in section "d," or still better, those shown in section "e" of Fig. 5.

In conclusion the following factors must be considered as the basis of modern classification of glass melting tanks.

a.—The presence of single or separated tanks and the method of their division;

b.—The presence of regenerators of recuperators;

c.—The flame direction in a furnace;

d.—The outlines of the tank;

e.—In furnaces with a dog-hole, the depth of the latter.

CHECKER-BRICK PERFORMANCE THEME OF REFRACTORIES DIVISION SUMMER MEETING

THE makers and users of refractories met in technical session at the summer meeting of the Refractories Division of the American Ceramic Society at Bedford Springs, Pa., Sept. 4-5, and engaged in a frank and informative debate on the properties and performance of checker brick. The place was well-chosen, both for its advantages as a mountain resort, and as to accessibility for most of the 65 people present who represented in particular the manufacturers of fire brick and steel.

Two men, each an expert in his field, read formal papers: J. D. Keller, research engineer of Carnegie Institute of Technology, and W. C. Buell, Jr. of Cleveland, engineer in open-hearth practice. The lively discussion which followed these excellent presentations brought out some comparisons between glass-tank and open-hearth practice, stated the demands made upon refractories by modern high-temperature furnaces, and drew able defensive remarks from the brick men.

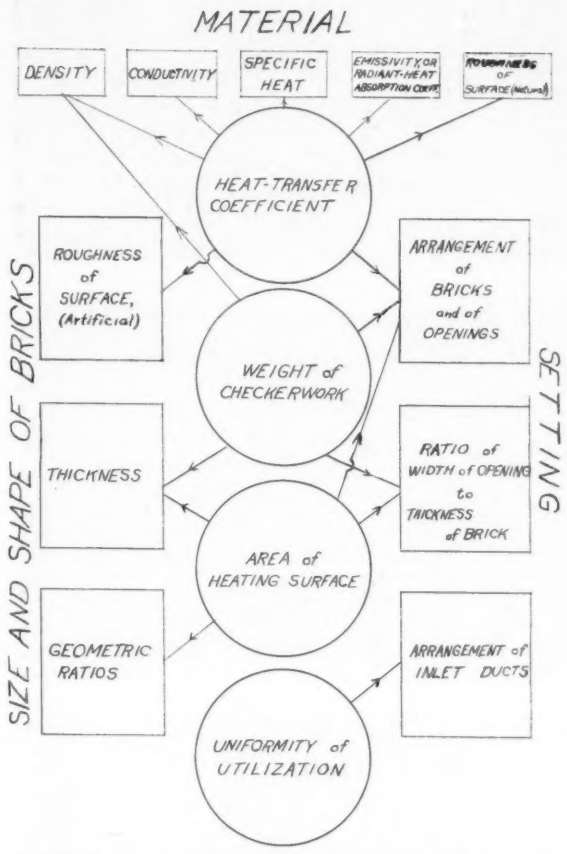
Mr. Keller's subject was, "The Influence of Material, Shape, and Size of Checker Brick on Regenerator Performance." He began by noting the general impression that the material of checker brick is very important, and that shapes, other than standard, and special methods of setting, might lead to greater efficiencies.

He stated that the differences between brick of different composition and properties (thermal conductivity, density, and specific heat) are only relative, and are greatly outweighed by other factors. The over-all heat-transfer coefficient, for example, is improved only 6 or 7 per cent by a ten-fold increase in conductivity.

Heat Flow—In the explanation of this astonishing statement, Mr. Keller showed curves indicating the temperature distributions in checker bricks at different periods in the operating cycle. The net effect demonstrated was, that in transmitting heat from out-going gas to in-coming air, the brick behaves as if it were the wall of a recuperator tile, a 2½-inch brick being about equivalent to a ¾-inch wall. Resistances to heat flow become the important considerations. The gas-to-brick resistance was rated at about 25 per cent of the total, the brick resistance at only 9 per cent, and the brick-to-air highest at about 66 per cent. A perfectly conducting brick could thus provide a gain of only 9 per cent in over-all transfer of heat. These figures apply to 2½-inch bricks and 15-minute reversals; thicker bricks and longer periods, also higher air velocities, would make greater gains possible, up to about 13 per cent for 4½-inch bricks and 30-minute reversals.

If cast iron, with its very high heat conductivity, could be used as a checker material, its variation of surface temperature from the mean, comparing in-going and out-going conditions, would show only ⅛ as much difference as would be found for fire-brick. But this allows a gain in over-all heat-transmission coefficient of less than 8 per cent.

Mr. Keller recited experience that he and Professor Trinks had gained, in testing hand-made and steam-pressed brick in an experimental regenerator. Although the steam-pressed brick had 15 per cent higher conductivity and also greater density, the hand-made brick were rougher, and consequently absorbed and radiated heat at a greater rate. Also, the rough surface increased turbulence of flow of gas and air. The net result was 8 per cent greater heat transfer for the hand-made brick, when both were new. This advantage would disappear, or be reversed, when dust deposit or glazing altered the surfaces.



• Relations of the main factors of Regeneration (Adapted from Keller).

Setting—Size and setting, said Mr. Keller, should be chosen to give maximum area consistent with high over-all heat-transfer coefficient. Greatest resistance is on the brick-to-air side, where convection, and not radiation, transfers the heat. Hence, the setting should produce all possible turbulence, within limits of draft loss. The usual flue-width (open-hearth practice) is about 6½ inches, with some as large as 10½, and others as small as 3½ inches. Much depends upon the construction of the slag pocket (a feature absent in the glass tank).

The speaker showed curves giving the calculated heat transfer of checker bricks of different thicknesses. With 30-minute reversals, a 2½-inch brick transmits 9 B.t.u. per sq. ft. per hr. per °F. difference, while a 1½-inch brick transmits 11 similar units. This affects only the brick coefficient, which is 8 to 12 per cent of the total.

In comparing the standard type of setting with the

• Photos snapped at Bedford Springs, Pa., by J. M. McKinley.

solid-chimney type, Mr. Keller pointed out that the chimney checker has more area of heating surface, more weight of brick per cubic foot, and also more effective surface for absorption by radiation and for convective heat transfer. There is more brick material, per unit of area, to supply heat to the surface, and the setting is more stable and durable against toppling. The disadvantages of the chimney setting are that if a flue becomes bridged over by dust or slag it is lost, because lateral flow is not possible; and there is certainly less convection than in the standard setting, whose open spaces set up turbulence. The standard setting shows 50 per cent higher heat transfer coefficient by convection. The conflicting influences appear, in practice, to balance very closely between the two types of setting.

Staggering the brick in the standard setting improves convection, but the risk of clogging is great. Method of setting does not affect "channeling," which is dependent upon inlet and outlet ducts.

Special Shapes—A number of slides were shown illustrating checker brick and tile of special shape, in use more especially abroad. These were discussed impartially, with the comment that special shapes and settings have not become popular in the United States. One style, consisting of short, elliptical rings set on end, appeared worthy of trial. This shape and setting provide: thin tiles of large heating surface, lateral flow, ease of cleaning, and great stability.

Weight—It was emphasized, that what is desired in a checker is heating surface rather than weight. While insufficient weight, with adequate heating surface, would cause too much variation in air temperature, in all the open-hearth checkers in actual use this fluctuation is not over 70° F. Extra-heavy checkers might retard the effect of unbalancing by unequal reversal periods, but would also retard recovery.

Summary:

1. New materials could make little improvement in checker bricks, unless they provide rougher surfaces.
2. Area of heating surface is more important than weight.
3. Considerable improvement is possible only by increasing the rate of brick-to-air transfer of heat.
4. Most promising avenues of improvement are (a) making brick shapes to increase turbulence and; (b) lessening dust and slag nuisance so as to permit smaller flues.

The most outstanding improvement, concluded Mr. Keller, would be the effective insulation and sealing of downtakes (open-hearth) to prevent the 300-400 degree temperature drop now occurring between ports and checkers.

Mr. Buell's Paper

MR. BUELL's paper was entitled, "Checker Brick in Open-Hearth Service." Prefacing his remarks with a quotation from one of his own books, the speaker said that progress in steel making had followed improvements in refractories and a better understanding of their use. Admittedly, the open-hearth furnace is the most severe of any of the regenerative furnaces in its demands upon checker brick, because of the high temperatures, the metallurgical effects, and the great changes in temperature during short reversal periods.

An illustrated description of the open-hearth checker-

chamber and flue construction interested the glass men present, because of the differences from glass-tank construction. Large slag pockets are provided immediately outside the ports, to catch dust and slag and prevent rapid fouling of the checkers. In the design shown, the outgoing gases entered the regenerator horizontally, and turned through 90° to pass through the checkers. The air checkers were on the inside. Checker-brick temperatures ranged from 950° F. at the bottom to 2600° F. at the top.

Notwithstanding the prevalent view of operators that brick size and setting have much to do with performance, Mr. Buell holds that "any design of checkerwork will be only as effective as the distribution of the fluids over and below the checkers." He presented diagrams of regenerator chambers, showing how the gases are directed by a "fantail" into the upper part of the chamber, and, by a "connecting flue," the entering air at the bottom.

The result, he showed, is often to throw the hot gases largely against the far side of the chamber as they pass down, and oppositely to bring most of the air up the comparatively unheated, near side. [*This is of interest, as calling attention to the over-heating of zones immediately under the uptakes in a glass-tank regenerator, while a large part of the regenerator fails to receive its share of the hot gases.—Ed.*]

The remedy proposed was one of design. The angles of the fantail and flue must be made more obtuse, so that the streams of flame-gases and air, respectively, enter the chamber in a more nearly lengthwise direction. Another plan offered was to use stepped-type checkers for chambers in which a turn has to be made, making successively narrower spaces above the checkers as the gases flow over them.

Dust, in which iron oxide predominates, is not effectively caught in the slag pockets, and is carried into the checkers, causing progressive deterioration. Mr. Buell showed how furnaces fall off in performance as they grow older, because of this fouling and slagging of the checker brick by dust.

Several types of setting were illustrated. One was the ordinary open flue, all brick on edge. A second showed an open flue, with alternate courses laid flat (2½-inch or 3-inch way.) The staggered flue has alternate courses off-set one-half a flue width. The fourth showed a chimney flue of interlocked construction. The speaker favored larger flues because of freedom from clogging, and argued that turbulence and equitable distribution of temperature in the moving column of gas will almost inevitably be maintained.

For checker maintenance, Mr. Buell recommends a definite plan of replacement. Since the top third of the checker brick must be discarded, all of them are to be removed, new brick put in for the bottom third, the old bottom third placed in the middle, and the middle third on top. In this way all the brick of the chamber eventually get the same length of service, well-seasoned brick are placed in the position of severe attack, and some salvage for other purposes is possible out of the discarded checkers.

The main point emphasized was, that checker brickwork itself is of less importance than the structural features of the regenerator and its flues.

(*Continued on next page*)

• Additional candid camera shots by Mr. McKinley.

• An informal group snapped in front of the Bedford Springs Hotel.

THE OPEN DISCUSSION

HESE papers were received with enthusiastic applause by the audience of 65 or more. Chairman *Ray E. Birch,* of Harbison-Walker Ref. Co., then led off the discussion, stating that the session was one in which the consumer's view-point was to have full attention. He mentioned the hoped-for advantages of denser brick and of the new "super-clay" brick offered by several manufacturers.

Arthur G. McKee, builder of blast furnace stoves, reciting the high efficiencies obtained in these by using small checkers and small openings, often as little as 1 11/16-inch square, suggested that some of the favorable factors could be carried over to open-hearth practice. He advocated making better dust pockets to clear the gases, then using smaller checkers and higher velocities.

Francis C. Flint, of Hazel-Atlas Glass Co., remarked that glass-tank practice parallels open-hearth. There is a somewhat lower temperature in the tank, but the gases reach the checkers very hot, and carry a good deal of batch dust, semi-molten, that is highly corrosive. He thought that the greatest need is a checker brick that will not slag too fast.

Mr. Capper, of Continental Roll and Steel Foundry Co., reported that he had used high velocities to advantage in fuel saving, but to the more rapid destruction of checkers. He also cited experiments on the introduction of solid particles (carbon) to increase radiation from the gases.

Mr. Ticknor, of Corning Glass Works, regarded the surface as the very important feature of checker brick, and said that any means of increasing the available surfaces would improve the slow transfer of heat from brick to air.

Mr. Siebert, of Bethlehem Steel, spoke of the unavoidably high temperatures of stack gases, and checker-chamber velocities of 12 to 17 feet per second, when furnaces are driven hard. Since fire-clay brick begins to shrink at 2150 to 2200° F., he was skeptical of getting more than 2200° preheat, and maintaining checkers any length of time.

W. H. Kelly, of Bethlehem Steel Co., commenting on other remarks about the seasoning of brick and making them more dense by use, said that newly-set checkers worked best.

J. M. McKinley, of North American Refractories Co., believed that the design of regenerative systems had not kept apace with furnace yields, and the result was the overworking and abuse of refractories. Checker chambers must be re-designed. He favored larger flue openings, in which more convection currents could arise, and correspondingly larger chambers. He pointed out that roofs of open-hearths stand up because they are protected by inert blankets of gas.

Louis J. Trostel, of General Refractories, called attention to the inherent properties of brick, and the limitations of the silica-alumina materials. He urged improvement of design.

Dr. Sossman, of United States Steel, mentioned the hopeful feature of solid particles added to gases, to assist in heat exchange.

Dr. N. W. Taylor, of Penn State, Secretary of the Division, and W. C. Rueckel, of H. Kappers Co., assisted the Chairman in conducting the technical and recreational affairs.

Activities at Bedford Springs were by no means confined to the technical session, a good part of the time having been devoted to social and recreational activities. On Friday, after the technical session, the membership enjoyed a banquet followed by dancing, and on Saturday the entire day was devoted to golf, swimming and to social activities, all of which combined to make this perhaps the most successful refractories meeting to date.

EQUIPMENT AND SUPPLIES

ANALYZES FLUE GAS SAMPLE IN 20 SECONDS

The Hays Corporation, Michigan City, Ind., makers of Orsatomats, reports that it has recently completed a portable analyzer for flue gas that will give accurate, reliable results even in the hands of an inexperienced and untrained operator. It is said to be possible to analyze a flue gas sample in only 20 seconds by simply moving one lever, the results being plainly indicated on a large legible scale.

The Orsatomat consists of a rotatable analyzing body which contains the measuring and absorption chambers and is charged with mercury and an absorbing chemical; the metallic bellows and linkage for moving the pointer; an aspirator bulb and the necessary rubber tubing; and a pressed steel case of a special non-tipping design, fitted with a convenient carrying handle.

The operator simply aspirates the sample into the instrument while it is in the sampling position (rod up). The automatic valve allows the gas in the sample to by-pass so that it is always measured at atmospheric pressure. The rod is then pushed down to the analyzing position, sealing the automatic valve and rotating the analyzing body causing the mercury in the analyzing body to flow to a new position. The liquid absorbing chemical floats on top of the mercury and the gas sample is displaced (by the movement of the mercury and chemical) from the measuring chamber into the absorption chamber where it is forced into intimate contact with steel wool saturated with the absorbing chemical. The absorption of the CO_2 causes a shrinkage in volume of the sample creating a vacuum which is transmitted to the pointer by the metallic bellows and read directly on the scale as per cent CO_2. The absorbing chemical will retain its strength for a long period and to recharge the instrument with the inexpensive fresh chemical is said to be a simple operation requiring only a few minutes.

The Union Mining Co., Pittsburgh, Pa., has appointed E. J. Bognar to serve as vice-president in charge of super refractories and director of research. Mr. Bognar was formerly connected with Corundite Refractories for nine years and during the past three years served as co-receiver and manager of that organization.

A NEW STRAIN TESTER

A new instrument, to be called the Fuess Polariscope, has been developed by R. Fuess, Inc., New York City for the testing of strain in glass. This polariscope works on the principle of a projector and shows the presence of strain in brilliant vivid colors on a glass screen. The glass to be examined is merely placed on the top surface of the instrument, and that is all that is required by way of manipulation. Results are said to be determined with exactitude and ease and may be viewed by a number of people simultaneously.

ROTARY LOUVRE DRYERS

The Link-Belt Co., 300 W. Pershing Road, Chicago, reports that it has acquired the manufacturing and sales rights for North America for the Dunford & Elliott rotary louvre dryer, many installations of which have been made in Europe, Canada and Japan. The dryer may be used for all types of granular materials, coarse or fine, or of irregular shape, size and consistency. It has also been used as a heating or cooling unit, as a general reaction vessel and for evaporating liquids on a solid substance.

THOMPSON TO HARBISON-WALKER

Dr. Clyde L. Thompson has recently become associated with Harbison-Walker Refractories Co. as a member of its Research Staff. Dr. Thompson is thoroughly experienced in petrography and his work as a consultant in that field is well known. He has done considerable work on thermal expansion of refractories by the interferometer method and on refractories used in glass tanks. Dr. Thompson is a graduate of the University of Illinois in Ceramic Engineering, holding the degrees of B.S., M.S. and Ph.D.

C. E. Noble has been appointed sales engineer by the Pyrometer Service Supply Corporation, Cleveland, Ohio. Mr. Noble was formerly with the E. C. Atkins Co., where he served as assistant metallurgist and also as a member of the sales organization.

WHERE HYDROFLUORIC ACID IS USED

"Haveg 43," a product of the Haveg Corporation, Newark, Del., is said to bid fair to replace lead wherever hydrofluoric acid is used in the production of glass. W. H. Adams, Jr., technical director of the Haveg Corporation, reports as follows on this lightweight material:

"We make two general grades of Haveg. The first called Haveg 41 is used for resistance to practically all acids except oxidizing acids like nitric acid; but it contains asbestos as a filler and is, therefore, not resistant to hydrofluoric acid and its related compounds.

"The Haveg 43 grade, on the other hand, is based on a carbonaceous filler which is unaffected by the hydrofluoric acid type of compound and has, therefore, found considerable use in the glass industry for etching tanks and many similar applications.

"Both grades of Haveg consist of a phenolic resin composition and it is this fact which largely explains their extreme acid resistance. Haveg of either grade is unaffected by rapid temperature changes and can meet temperatures as high as 265° F. without damage. Both grades have adequate physical strength which permits the production of self-supporting articles even in larger sizes. Haveg 43, the grade resistant to hydrofluoric acid compounds, is not, however, quite as strong as the general grade, Haveg 41.

"The process by which Haveg is made consists of a moulding technique which practically eliminates the mould expense which would be tremendous on large equipment. This makes economically possible the production of large tanks, towers and other equipment in a single seamless piece in sizes up to nine feet in diameter by nine feet deep.

"The utilization of Haveg 43 in the glass industry is based on its resistance to hydrofluoric acid, and has had a wide spread and very successful use along these lines. There are places in the glass industry, of course, where sulphuric acid and other acids are used, particularly in washing operations and, for these applications, the regular grade Haveg has also been used extensively.

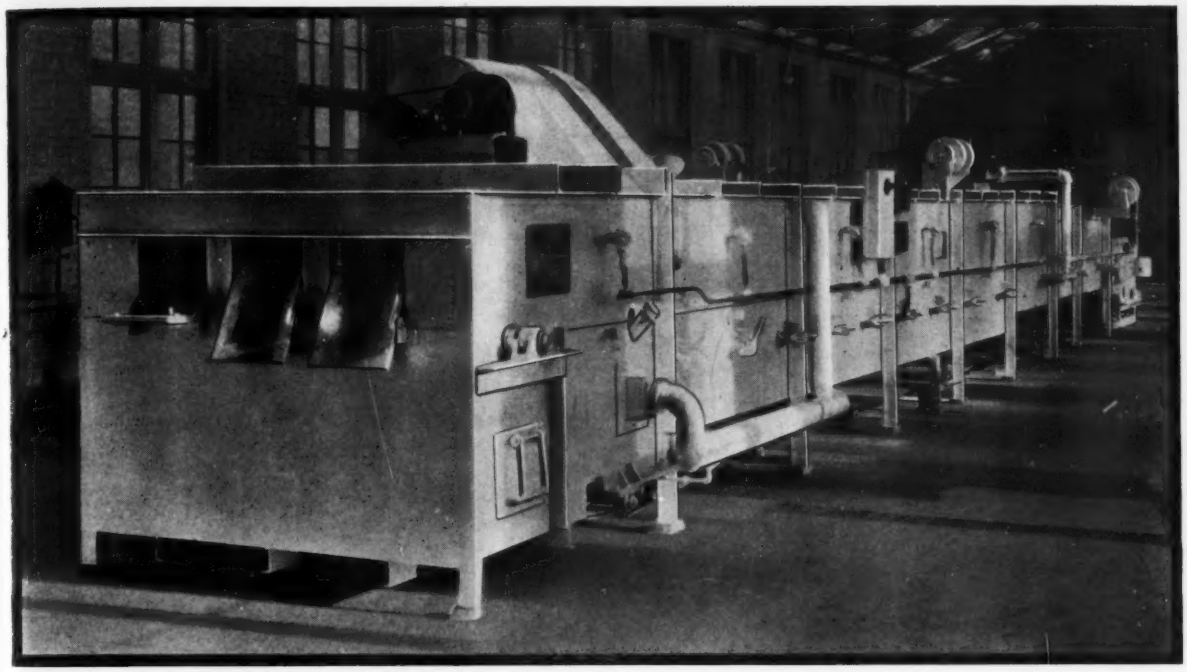
Two cylindrical Haveg tanks being used in hydrofluoric acid serves in the glass industry.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks	Per 100 lb.	...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.15
52% and 48%	lb.	.10	.12½-.11½
Nitric (HNO_3) 130 lb. carboy ext.	Per 100 lb.	...	5.50
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	..
Tartaric	lb.	... Po. or Gr. / Cry.	.25 / .25½
Aluminum hydrate (Al (OH)3)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.0515	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.15
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	.12	.12½
Antimony oxide (Sb_2O_3)	lb.	...	.12¾
Antimony sulphide (Sb_2S_3)	lb.	...	.13
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite)			
90%, 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	38.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.05	.05¾
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.07¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
(Commercial, 25% Selenit.m)	lb.	...	.90
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated	In bags, lb.	.022	.0245-.027
Powdered	In bags, lb.	.0245	.027-.0295
Boric acid (H_3BO_3) granulated	In bags, lb.	.05	.0525-.055
Cadmium sulphide (CdS)—	lb.	...	.90-.95
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	.0215
Cerium hydrate			
100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	.17	.215-.25
Cobalt oxide (Co_3O_4)			
In bbls.	lb	...	1.41
In 10 lb. tins	lb.	...	1.51
Copper oxide			
Red (Cu_2O)	lb.	...	.20
Black (CuO)	lb.	...	.15
Black prepared	lb.	...	.22
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08½	.09
Feldspar—			
20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	31.50	...
In bags	ton	33.10	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide—			
Red (Fe_2O_3)	lb.	...	.0425
Black (Fe_3O_4)	lb.	.04½	...
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	...
English, lun.p, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.0710	...
In 5 Ton lots	lb.	...	.075
Less than 5 Tons	lb.	...	.08

		Carlots	Less Carlots
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)	ton	1.75	...
Litharge (PbO) (New York Prices)	lb.	.0610	...
In 5 Ton lots	lb.		.065
Less than 5 Tons	lb.	.	.07
Magnesium carbonate ($MgCO_3$)	lb.	.0610	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.0275
Manganese, Black Oxide			
In Paper bags	ton	47.50	50.50
In Burlap bags	ton	49.50	52.50-57.50
In Casks	ton	51.50	54.50-59.50
Neodymidm oxalate, 50 lb. drums	lb.	...	$3.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb.	...	.09
Powdered	lb.	...	.09½
Potassium carbonate			
Calcined (K_2CO_3) 96-98%	lb.	.06⅞	.07⅛
Hydrated 80-85%	lb.	.06	.06¼-.06⅜
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	...	.27
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	.0545	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.18¾-.19¾
Rare earth hydrate			
100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.30
Rochelle salts, bbls.	lb.	...	.12½
Rouge	lb.	... Po. or Gr. / Cry.	.13½
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se) In 100 lb. lots	lb.	...	2.00
In lesser quantities	lb.	...	2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.)	per oz.	...	.39
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.07
Sodium chromate (Na_2CrO_4) Anhydrous	lb.	...	.08⅛
Sodium fluosilicate (Na_2SiF_6)	lb.	.07	.07½
Sodium hydrate (NaOH) (caustic soda)			
Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	...
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls.	Per 100 lb.	...	2.00-2.25
95% and 97%			
Bulk	Per 100 lb.	1.225	...
200 lb bags		1.29	1.34
100 lb. bags		1.325	1.375
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	...	1.50-1.55
Yellow	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) . in bbls.	lb.	...	.35
Tin oxide (SnO_2) in bbls	lb.	...	$.49
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	2.25
Yellow orange	lb.	...	1.50
Zinc oxide (ZnO)			
American process, Bags	lb.	.05¼	.05½
White Seal, 150 lb. bbls.	lb.	.07	.07¼
Green Seal bags	lb.	.06¼	.06½
Domestic White Seal bags	lb.	.06¾	.07
Red Seal, bags	lb.	.05¾	.06
Zircon			
Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude, Gran. (Milled .005-.02c higher)		.03½	.04-.05



SOLVING NEW PROBLEMS FOR THE GLASS INDUSTRY

● During the past year production men in the glass industry have faced many new problems, such as annealing at higher temperatures, melting special glasses at higher temperatures with increased flexibility, glass heat treating to accomplish certain definite results in the finished product.

These new problems in production have raised corresponding and related problems in equipment—the proper selection of structural materials to withstand higher temperatures, increased flexibility in heat distribution, improved temperature and atmosphere control.

As indicated by the photographs of some recent SC installations shown above, production men in the glass industry have turned to Surface Combustion as an organization with laboratory and manufacturing facilities, with engineering experience and personnel, schooled in the solution of heat treating problems for industry. They have found there an understanding and appreciation of their problems and needs, and an ability to interpret engineering facts into practical furnace construction, which includes the selection of proper materials, the determination of proper sizes, the designing and construction of practical furnaces for special needs as well as for regular production requirements. The satisfactory results obtained in actual operation are now a matter of production records.

Surface Combustion developments are available for finishing and conditioning, as well as for melting and annealing. May we tell you how you can investigate these new developments for yourself?

WHAT IS *Your* PROBLEM?

Do you need equipment to:

- Anneal at higher temperatures
- Melt Special Glasses at higher temperatures
- Accomplish unusual results in finished product
- Anneal ware traveling at different speeds in same lehr
- Heat glass from cold for hardening
- Heat glass for molding
- Anneal glass requiring different temperatures in same lehr at same time
- Anneal special ware on high speed conveyors
- Anneal optical glass
- Increase annealing capacity with limited space for lehr

Whatever the job to be done—whether it ever has been done before or not—if it has to do with heat treating, submit it to SC Engineers.

SC LEHR
THE ONLY LEHR WITH
Controlled Recirculation

Surface Combustion Corporation

TOLEDO, OHIO (SC) ***Sales and Engineering Service in Principal Cities***

GLASS CONTAINER REPORTS

(*Continued from page* 345)

his average wage per annum increased from 654 to 1,088 dollars, or more than 60 per cent.

2. Along with this wage increase, there has been a decided drop in hours of labor. While the table makes no reference to hours of work, it is possible, none the less, to gain a fair idea of the extent to which glass workers have benefited. Figures for all industry, released on Sept. 16 by the National Industrial Conference Board, show that hours of work in manufacturing have dropped 23 per cent since 1914. And this closely approximates conditions in the glass industry. Wages for all industry have increased 39 per cent, after taking into account increases in the cost of living.

3. What a story the tax figures reveal! An increase from $370,500 in 1914 to $4,568,700 in 1935. More than 12 times what they were in pre-war days.

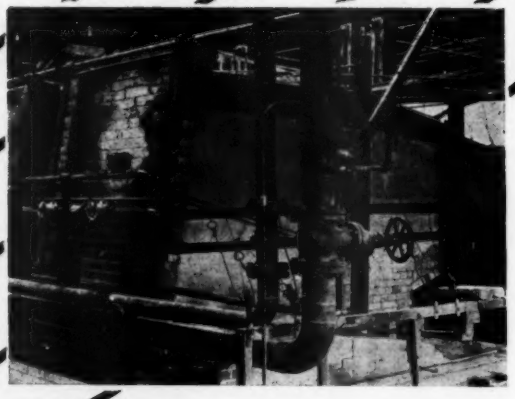
4. How have these additional costs affected the buyer of glassware? If figured on a tonnage basis, we find the price of glass containers has increased from $2.117 to only $2.354 per hundred weight. The buyer of glass containers truly does get more for his dollar today than he does buying almost any commodity one could name!

C. R. Stevenson, manager of the Association, concluded the session with an address devoted largely to the Robinson-Patman Act. The disposition of industry generally, said Mr. Stevenson, at first was to take the matter lightly, many believing its ambiguities and the doubtful constitutionality of many of its provisions would invalidate the measure. Now, counsel is generally of the opinion that in its main essentials, the Act is constitutional. Mr. Stevenson alluded to the days when price discrimination was a common practice among the freight carriers, and how those practices were stopped by the Act creating the Interstate Commerce Commission. Industry benefited greatly from this legislation, and since that time the trend of its thinking has always been in support of it. The Robinson-Patman Act corrects similar abuses, and in its main provisions will probably be regarded by the courts as of the same validity.

In all probability, said Mr. Stevenson, the Act could be circumvented in many ways. But glass men see in it the means of correcting many trade abuses and they are accepting the law in this spirit. With the passage of time, Mr. Stevenson believes, most industries will come to feel the same way about it. Time will be required before legal interpretations can clarify much of its obscure and ambiguous provisions, but meanwhile, instead of worrying about this, the manufacturer is well advised to live up to the Act as best he can.

The Association paid tribute to the memory of the late Philip I. Heuisler, former president of G. C. A. and president of the Maryland Glass Corporation, by standing in silent prayer. It was also announced that J. Stanley Heuisler had been elected a director of the Association to fill the vacancy caused by his father's death.

The L. J. Honze Convex Glass Co., Point Marion, Pa., is building a large addition to their plant which includes 10 new furnaces. Plans for a small chemical laboratory are also being drawn up.



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Patents Pending

The controlled luminous flame method of firing as developed by Toledo Engineers has proven in actual production to deliver the highest degree of efficiency in glass furnace operation.

Specialization in glass plant engineering assures users of our service of the most advanced technique in glasshouse planning. Proven and practical installations of all types of equipment are the foundation of our business.

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958 Wall Street, Toledo, Ohio

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- The *most profitable* solution of glass plant problems has been found in Simplex machinery. Used wherever glass is manufactured, it is recognized for its outstanding engineering principles and endurance.

- Simplex equipment assures • lower manufacturing and maintainance costs • no waste of time or labor through production interruption • smooth and continuous performance.

Consider the greater profits which result from these advantages in plant operation!

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